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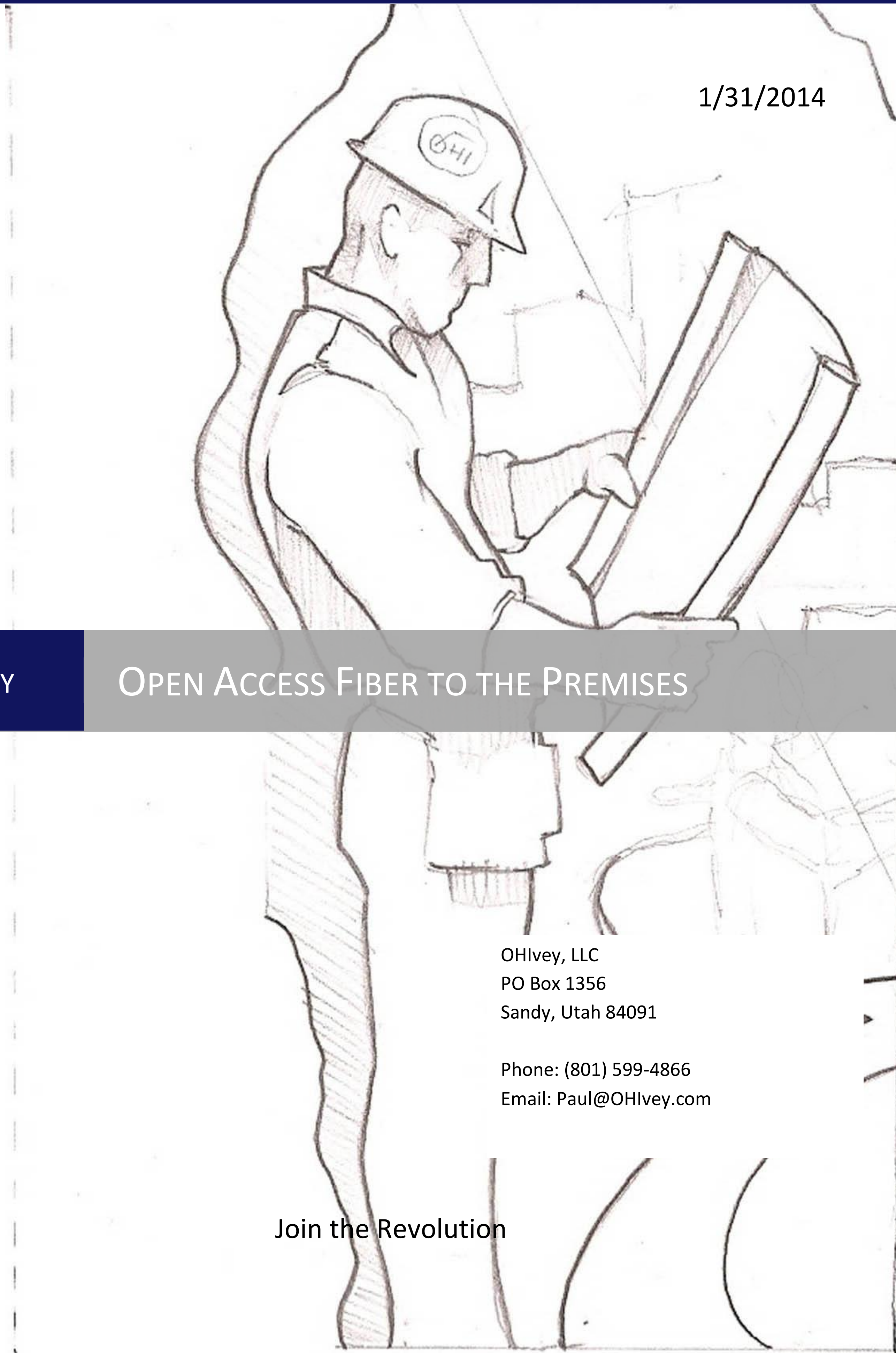

OHIvey

Open Access Fiber to the Premises

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Join the Revolution


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Executive Summary

We understand the following response to Louisville Metro Government's "Request for Information: Broadband Infrastructure Upgrade and Expansion" may be a little lengthier than you might hope. We feel it is important to lay out our fundamental philosophy and to present a solution we believe meets LMG's goals.

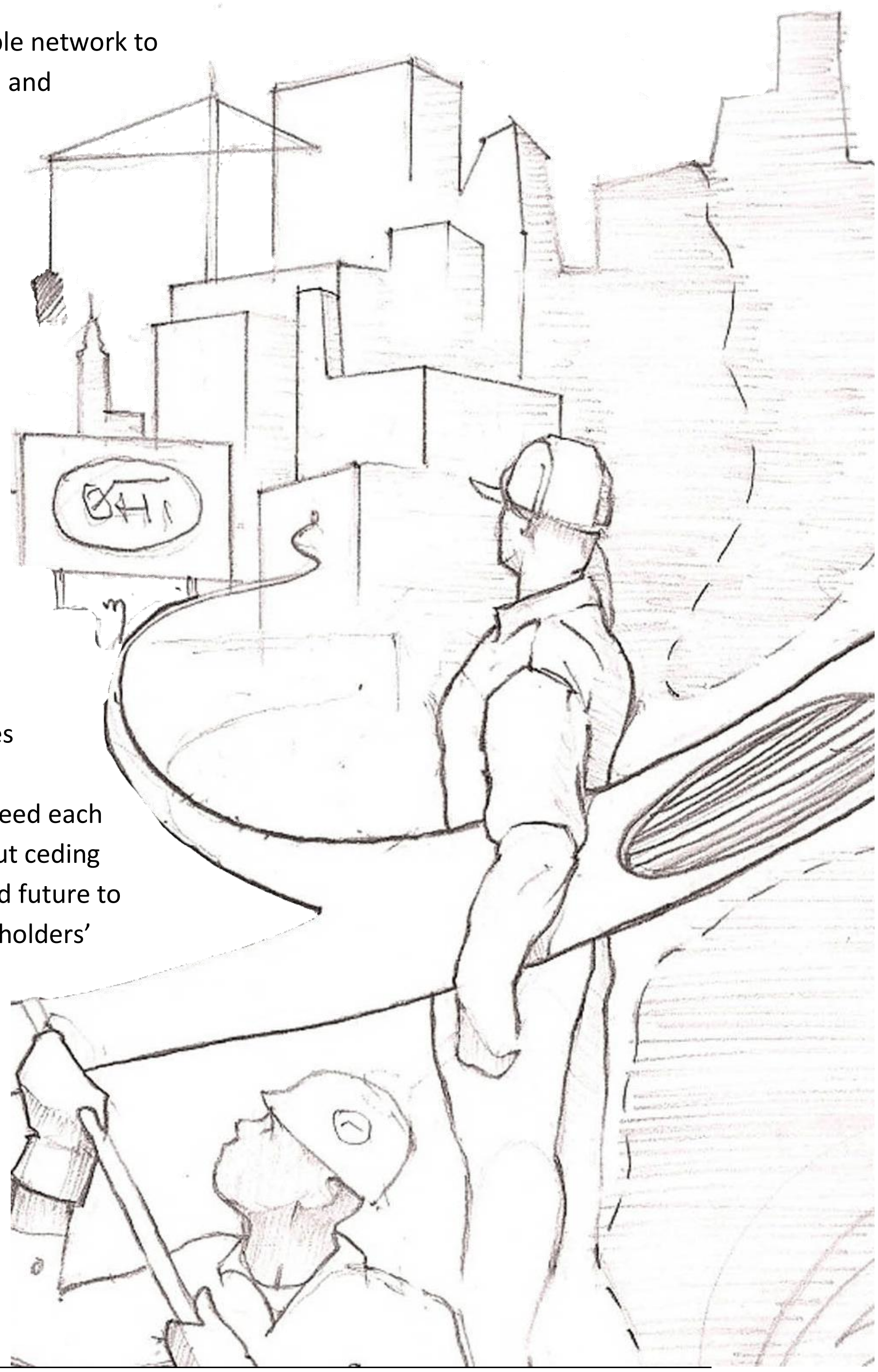
The objectives described in the RFI, indicate LMG hopes to:

1. Create a world-leading gigabit-capable network to foster innovation, drive job creation, and stimulate economic growth,
2. Provide free or heavily-discounted 100 Mbps or better Internet service to underserved and disadvantaged residential areas, and
3. Deliver gigabit Internet service at prices comparable to other gigabit fiber communities across the nation.

The objectives are further clarified in that LMG intends to accomplish these goals without acting as a retail service provider or network operator.

The ubiquitously deployed public-private partnership open access fiber to the premises model described in this report represents a methodology whereby LMG can meet or exceed each of its objectives with minimal risk and without ceding control of the metropolitan area's broadband future to private companies who must put their shareholders' interests ahead of public policy. We believe this solution is the only solution that meets all of LMG's objectives.

The proposed solution has several potential iterations. The general outline suggests:



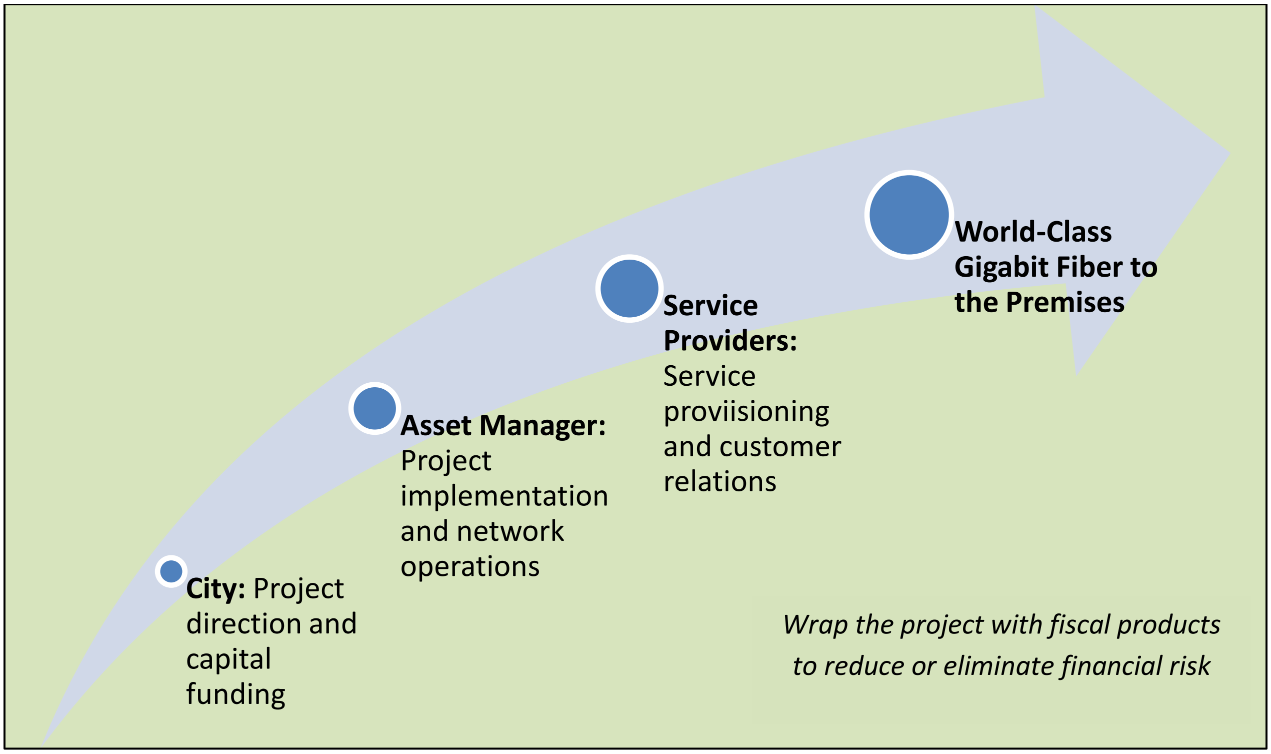


Figure 1: Solution Elements

To sum up the proposed model, let's look at the "Guidance for Responses" from the RFI:

- *Strategies included in responses to the RFI should aim for forward-looking, assertive technology solutions that create immediate advantages for users and fertile platforms for innovations in products and services that sustain our technology leadership for years to come.*
  Both the proposed active Ethernet technology with cascading aggregation and the open access business model are forward-looking solutions that create immediate advantages for users and fertile platforms for innovations in product and services that sustain technology leadership.
  The active Ethernet technology with cascading aggregation allows for maximum bandwidth to each subscribing address with maximum reliability. The architecture is easily upgradable as advances in electronics are made and, with relief planning built into the outside plant design, physical fiber path capacity can be increased at reasonable costs with minimal disruption.
  The open access business model spreads the responsibility for innovation across multiple partners vested in the success of the project. No longer is creativity constrained to the minds within a single organization but rather many competing companies are all working to bring the best and most innovative new services to the market.
- *High bandwidth in the upstream direction is considered essential.*
  The proposed active Ethernet model is designed for symmetrical bandwidth.
- *Some or all of a respondent's proposed service offerings could initially be at speeds below the thresholds so long as the overall strategy furthers the goals of broadband innovation and development. While LMG shares a belief that ultra-high-speed broadband networks are a pre-*

requisite for ongoing advances in a number of disciplines, end-users in our city have a wide-range of networking needs and use-cases. We do not anticipate that all areas in Louisville would receive access to similar speeds at similar times.

The financial success of the project depends on either capturing significant market share or being able to charge high margin rates. The marketplace (and LMG's goal of offering gigabit speeds at comparable prices to other projects throughout the nation) does not allow for charging high margin rates, therefore, the project must capture significant market share. This can only be done by a) offering products that are significantly differentiated from traditional broadband products and giving consumers a compelling reason to switch to fiber, b) taking advantage of network effects to maximize diffusion, c) minimizing implementation and operations costs by maximizing economies of scale, and d) providing a large enough marketplace to support multiple competing service providers. Therefore, we propose that service offerings must offer ultra-high-speed broadband to as large an area as can be reasonably established and that the network must be ubiquitously deployed in as timely fashion as possible.

- *Respondents should feel free to propose alternative business models and network solutions that could be used to meet LMG's needs.*

  We feel our business model represents a revolutionary alternative to the historic models that have left Louisville and the rest of the nation with our lagging broadband legacy. We invite Louisville to join the revolution and to take control of your own broadband future.

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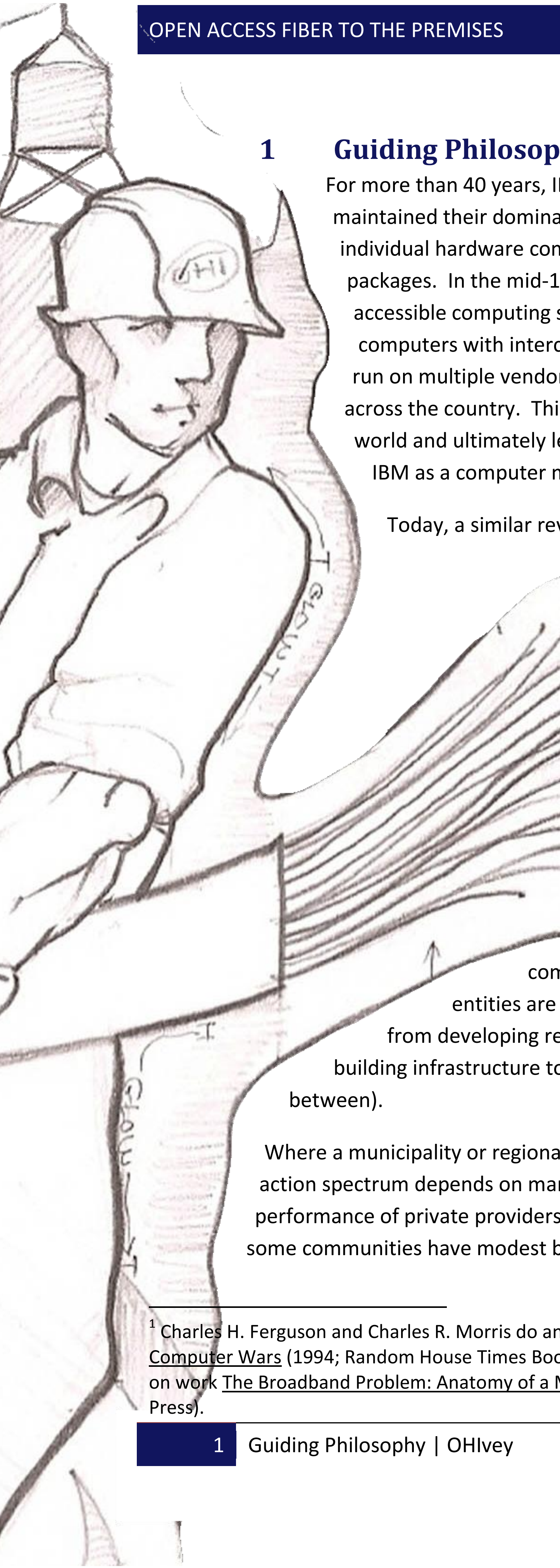

1 Guiding Philosophy

For more than 40 years, IBM dominated all aspects of the computing business. IBM maintained their dominance in part by tying application software to hardware and individual hardware components together in tightly controlled proprietary packages. In the mid-1970's, IBM misread the growing demand for smaller, more accessible computing services. A grass roots revolution to create "personal" computers with interchangeable components and application software that could run on multiple vendors' hardware platforms grew in basements and garages across the country. This "open" model was a disruptive force in the computing world and ultimately led to the marginalization of mainframe computers and of IBM as a computer manufacturer[1].

Today, a similar revolution is growing in the telecommunications industry. For decades, Bell Telephone, the "Baby Bells" and a handful of cable providers have maintained monopolistic control of telecommunications networks throughout the country. Many municipalities, cooperatives, and other organizations are recognizing a growing grass roots demand for true consumer choice on true broadband networks that simply is not being met through traditional telecommunications delivery models. To meet the needs of their constituents – to accomplish goals of creating world-leading gigabit-capable networks, providing discounted Internet service to underserved and disadvantaged residential areas, delivering gigabit Internet service at prices comparable with other gigabit communities across the nation, and so forth – many public entities are stepping into broadband development by taking action from developing regional broadband plans to lowering entry barriers to building infrastructure to operating fully competitive networks (and everything in between).

Where a municipality or regional government falls on the public broadband development action spectrum depends on many factors. Some communities have full confidence in the performance of private providers – others feel trapped by their local incumbents' inaction; some communities have modest broadband development goals – others hope to compete on

[1] Charles H. Ferguson and Charles R. Morris do an excellent job of chronicling the rise and fall of IBM in their book Computer Wars (1994; Random House Times Books). Ferguson uses the example of IBM extensively in his follow on work The Broadband Problem: Anatomy of a Market Failure and Policy Dilemma (2004; Brookings Institution Press).

a global stage; some communities accept broadband deployment red lining and cherry picking as an unfortunate but unavoidable condition – others believe the digital divide is driving a wedge through their neighborhoods; some communities believe market solutions will resolve their broadband issues – others see infrastructure as a natural monopoly and the lack of competition engendered by that natural monopoly contributing to a market failure that has left the United States trailing much of the developed world in broadband quality, price, and adoption.

At OHIvey, we believe that only a fundamental change in broadband delivery practices will result in a fundamental change in broadband quality, price, and adoption. In the course of this report we will show how the Louisville Metro Government can meet the objectives outlined in the "Request for Information: Broadband Infrastructure Upgrade and Expansion" through a dramatic shift in broadband delivery mechanism thinking. We will show you why we call on Louisville and metropolitan areas around the country to join the revolution.

Much like the rail systems of the late 1800's, today's advanced communications infrastructures represent a means by which communities may participate in, or find themselves left out of, the global economy[2]. Many communities are discovering that critical telecommunications needs in their business and residential markets are going unmet. Incumbent network owners consume limited public easement space with monopoly controlled networks. Historic telecommunications business practices and market forces encourage these private companies to work towards broadening their revenue streams by extending their natural monopoly through vertical integration leading to cable companies acquiring content producers and traditional telephone companies merging with wireless providers. Quarterly reporting requirements demand behavior that maximizes short term profits. This leads to incumbents delaying infrastructure upgrades – not only to avoid capital costs but also to maintain the appearance of bandwidth scarcity allowing companies to charge higher prices for lower quality than found in many other countries around the world. However, advanced communications infrastructures are essential for the current and future economic vitality of communities. Communities have begun to see the need to break the cycle of monopoly driven scarcity and vertical integration. In the 19th century city councils struggled with ways to entice the railroad barons to include them in transportation systems. In the 20th century cities and towns became experts at deploying critical infrastructure including, roads, electricity, and water. In the 21st century public policy demands that rather than begging and pleading with the incumbent providers, municipalities apply their infrastructure skills to improving broadband availability and competition.

To begin we would like to explore the current state of broadband, review LMG's expressed goals, and define some guiding principles. Then we will turn our attention to the five areas of information LMG has asked respondents to address outlined in the request for information following the "Guidance for Responses" section.

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[2] In Railroaded: The Transcontintentals and the Making of Modern America, Richard White shows economic thinking in the late 1800's demanded a conversion from overbuild competition to railroad and telegraph monopolies; monopolies that could be sustained regardless of the arrogance of power, the impact of inept leadership, or the fleecing of customers.

1.1 Current State of Broadband

It is unlikely incumbent providers will work aggressively to pursue the public policy benefits sought by LMG and other communities across the country. The US lags behind the rest of the developed world in broadband capacity, quality, and adoption. Both history and current policy lead incumbent telecommunications providers to consolidate and protect their monopoly positions. Once secure in their monopoly, Wall Street discourages the capital investment required to upgrade 20th century architectures to meet the ever expanding need of the 21st century.

1.1.1 Broadband in the US and Louisville is Inadequate

First, let's look at broadband in the US and then in Louisville.

1.1.1.1 US Broadband Lags Behind other Developed Nations

Many incumbents argue the bandwidth they provide is more than adequate and, that as soon as the market demands it be done, they will upgrade their services. This argument sounds like the one Henry Ford made when he said of the Model-T in 1909, "Any customer can have a car painted any color that he wants so long as it is black." More germane to the current discussion is the flood of telephone styles that came to market after AT&T abandoned their telephone device monopoly. Prior to allowing competing handsets, AT&T claimed that the market did not demand anything other than the traditional black cradle phone. In the case of bandwidth, like with colors of automobiles and styles of phones, more availability creates more demand.

What allegorical black Model-T's and cradle phones are today's equivalents of Henry Ford and AT&T offering US broadband customers?

The OECD compares international advertised download speeds among 34 member countries. Their 2011 comparison puts the US, with its average advertised download speeds of 27.6 Mbps at a poor 19th place[3].

[3] OECD (September 2012). "Average and Median Advertised Download Speeds". Retrieved 10 Oct 2013 from http://www.oecd.org/sti/broadband/BB-Portal-5a.xls.

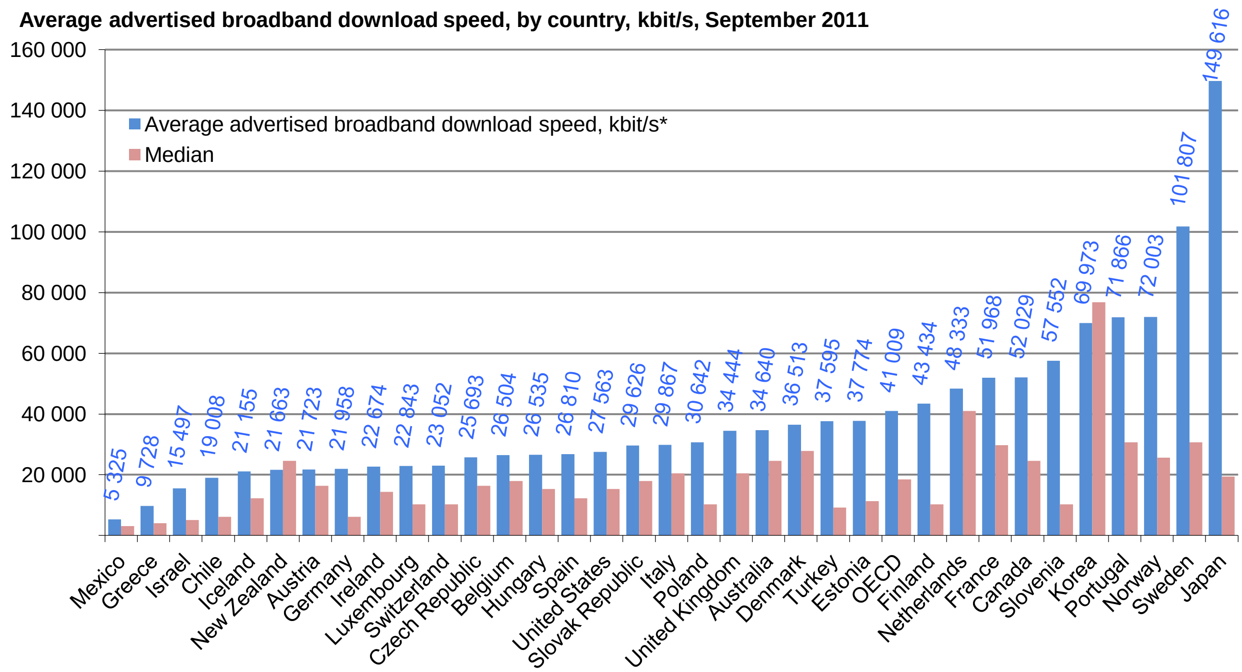

Figure 2: OECD Average Advertised Broadband Download Speed by Country

Nationally, the Information and Technology Innovation Foundation has ranked the United States fifteenth out of the thirty advanced nations studied in a comparison of the quality of broadband connections based on the percentage of households with access, the speed of the connections, and costs[4]. Based on speed alone, the US ranks even lower – at 25th according to a survey by Speed Matters[5]. "Figure 3: Global Broadband Quality and Penetration Leaders"[6] shows the US lagging behind other developed countries in broadband measures of both quality and penetration.

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4 Atkinson, Robert D., Daniel K. Correa and Julie A. Hedlund (May 2008). "Explaining International Broadband Leadership." The Information Technology and Innovation Foundation. Retrieved 12 September 2011 from http://www.itif.org/files/ExplainingBBLeadership.pdf.

5 Speed Matters (November 2010). "2010 – A Report on Internet Speeds in All 50 States." Communications Workers of America; Washington DC. Retrieved 24 January 2012 from http://cwa.3cdn.net/299ed94e144d5adeb1_mlblqoxe9.pdf.

6 "Figure 3: Global Broadband Quality and Penetration Leaders" and the data supporting it come from the Said Business School's (University of Oxford) "Third Annual Broadband Study Shows Global Broadband Quality Improves by 24% in One Year" published in 2010.

Figure 3: Global Broadband Quality and Penetration Leaders

In "The Global Competitiveness Report 2011-2012," the World Economic Forum ranked the US 18th in Internet users/100 population, 18th in broadband Internet subscriptions/100 population and 26th in Internet bandwidth measured as kb/s/capita (p 363)[7]. Lagging in broadband quality and penetration hurts US competition on the world stage.

Some pundits claim these data are dated and that US companies have made significant progress closing the international broadband gap. A check of Google Analytics public data ranks average US download speeds 31st of measured countries[8] and 40th for average upload speeds[9].

[7] Said Business School, University of Oxford (1 October 2009). "Global Broadband Quality Study Shows Progress, Highlights Broadband Quality Gap: Broadband Quality Improves around the World Despite Economic Downturn." University of Oxford; London. Retrieved 24 Feb 2012 from http://www.sbs.ox.ac.uk/newsandevents/Documents/BQS%202009%20final.doc.

[8] Screenshot taken 17 January 2014 from http://www.google.com/publicdata/explore?ds=z8ii06k9csels2_#!ctype=c&strail=false&bcs=d&nselm=s&met_y=avg_download_speed&scale_y=lin&ind_y=false&ifdim=country&hl=en_US&dl=en_US&ind=false.

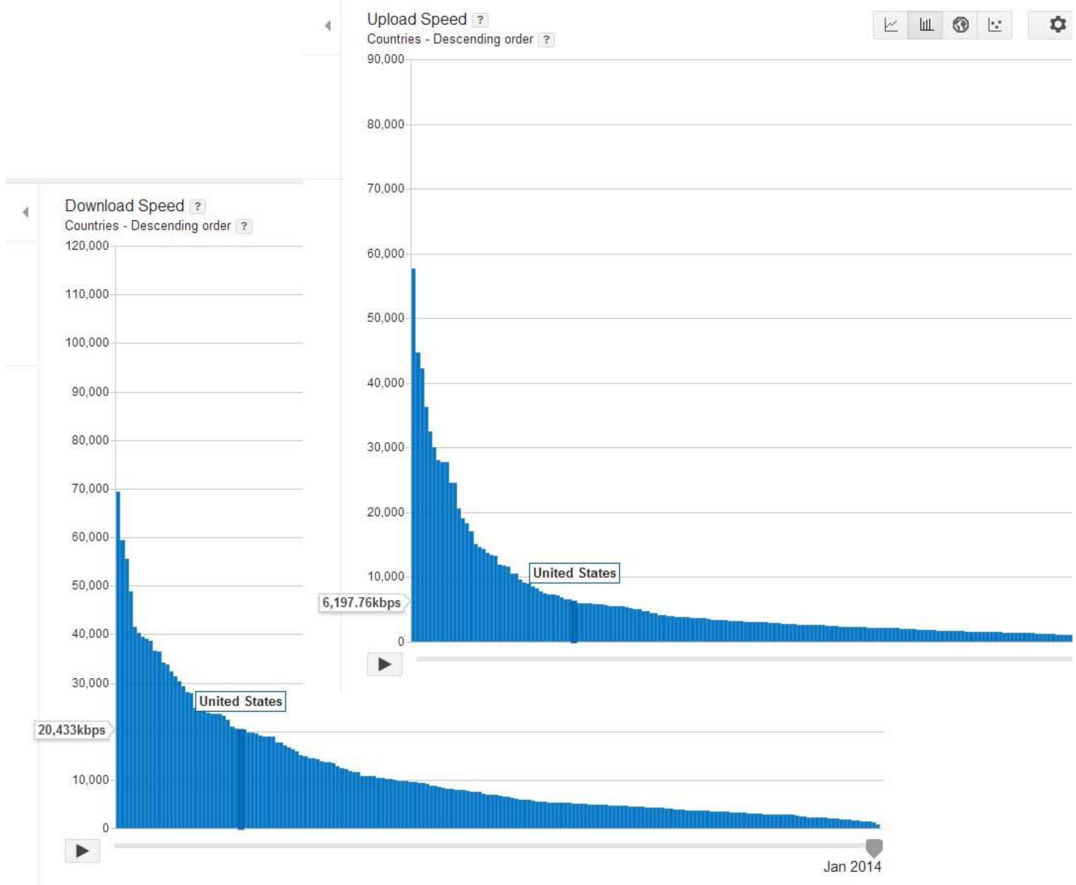

Figure 4: Google Analytics International Download and Upload Speed Comparisons

1.1.1.2 Broadband in Louisville is inadequate

TestMy.net compiles actual speed test data. Their data suggest the US has actual average download speeds of 13.8 Mbps[10]. The City of Louisville performs a little better than the US average with a TestMy.net average download speed of 14.6 Mbps[11].

[9] Screenshot taken 17 January 2014 from http://www.google.com/publicdata/explore?ds=z8ii06k9csels2_#!ctype=c&strail=false&bcs=d&nselm=s&met_y=avg_upload_speed&scale_y=lin&ind_y=false&ifdim=country&hl=en_US&dl=en_US&ind=false.

[10] Data collected 20 January 2014 at http://testmy.net/country.

[11] Screen capture taken 20 January 2014 from http://testmy.net/hoststats (modified to remove advertisements).

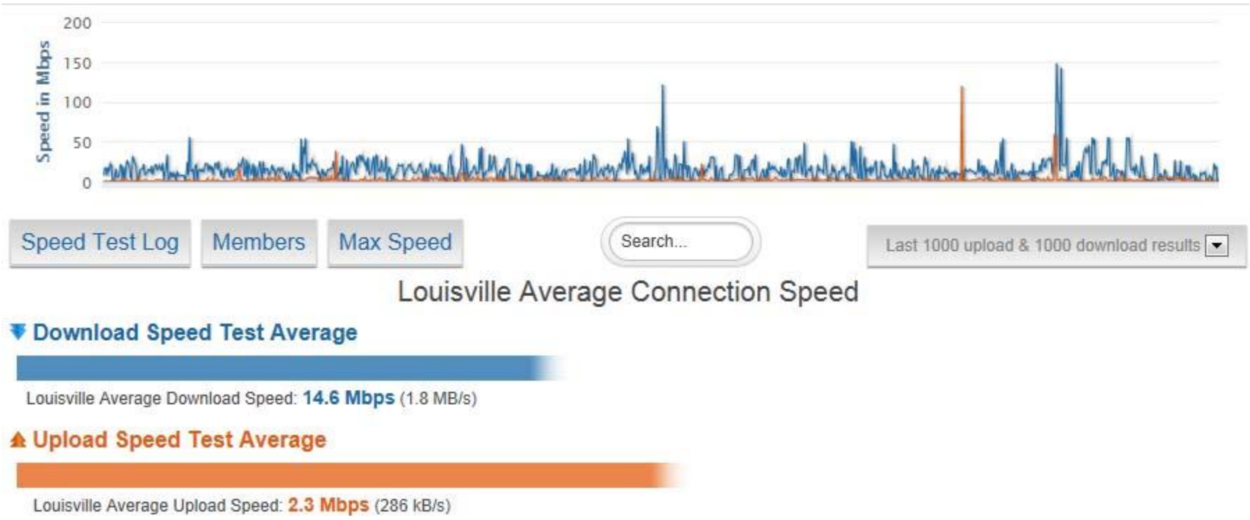

Figure 5: TestMy.net Results for Louisville

Louisville's 14.6 Mbps average download speed places it sixth among the ten US cities nearest Louisville in population[12] and leaves the City with an average download speed that is only 16% of the speeds in the US's fastest city of Harvey, LA[13] and only 9.7% of the average advertised speed of nearly 150 Mbps in Japan.

[12] Population data collected 20 January 2014 from http://en.wikipedia.org/wiki/List_of_United_States_cities_by_population.
[13] Speed test data collected 20 January 2014 from http://testmy.net/country.

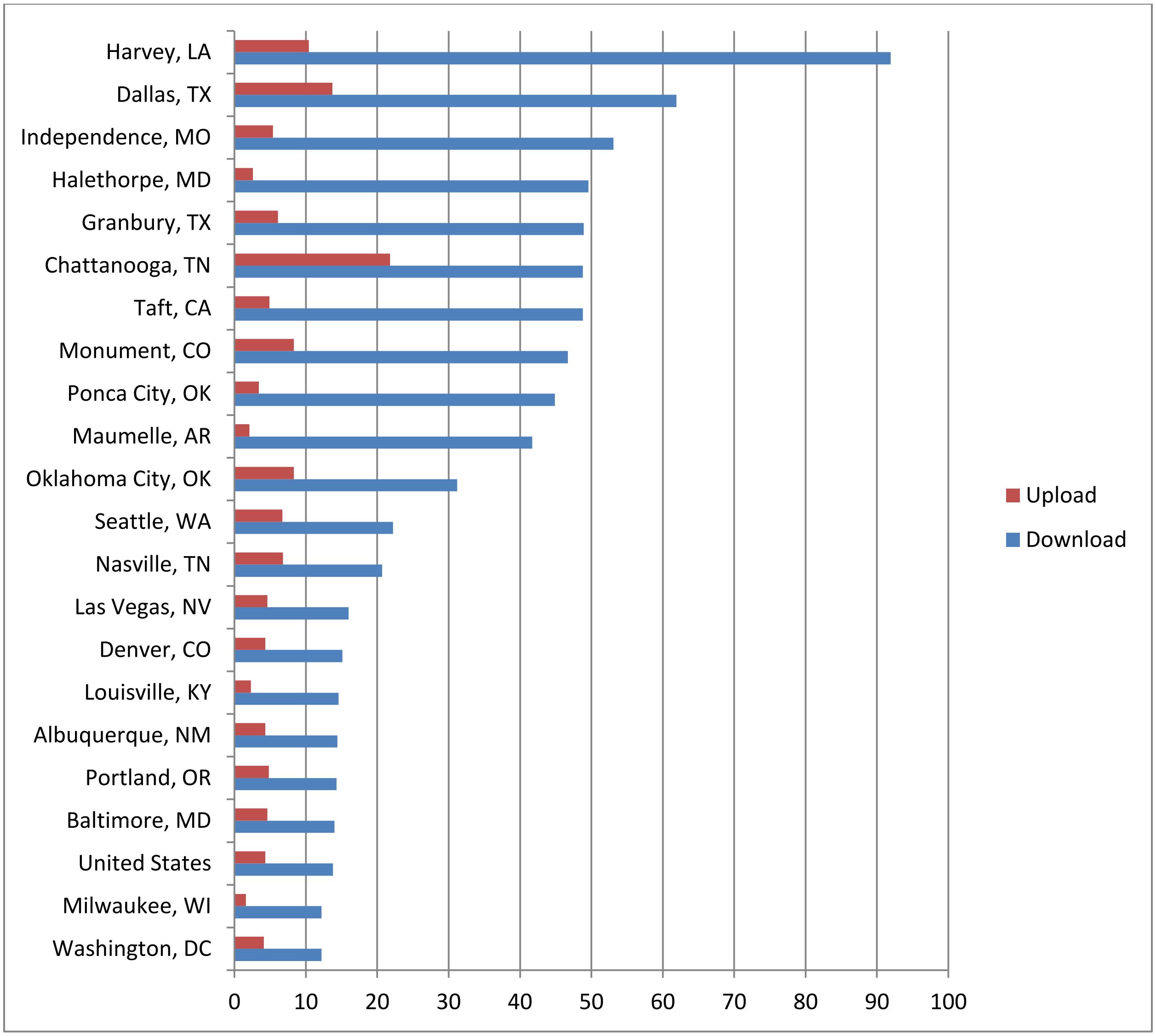

Figure 6: TestMy.Net Speed Test Results for 10 Fastest US Cities and 10 Cities of Similar Population to Louisville

1.1.2 Historic Context for Lagging Broadband

The state of broadband in the US and Louisville is a result of the history of broadband in the US, the current regulatory environment, and pressures from Wall Street.

1.1.2.1 US Telecommunication History has Encouraged Private Enterprise Monopolization

In 1838 the US Congress appropriated $30,000 to fund construction of the first commercial telegraph line from Washington DC to Baltimore. On its opening day, Samuel Morse inaugurated modern telecommunications by tapping out, “What hath God wrought.” While we cannot attribute the results to God, what was wrought was the beginnings of government backed monopoly of telecommunications systems that pervades US markets still today.

Open access is not a concept traditionally espoused by the telecommunications industry. In 1907 Theodore Vail, the President of AT&T, described the concept of, "One Policy, One System, Universal Service." Vail said, "Competition – effective, aggressive competition – means strife, industrial warfare; it means contention; it oftentimes means taking advantage of or resorting to any means that the conscience of the contestants or the degree of the enforcement of the laws will permit." He contended that this type of contest would undermine the ability of the telephone system, a system by virtue of its interconnect requirements and its network effects (a term Vail introduced in 1908) was a natural monopoly, to function in its public role. In his efforts to bolster his natural monopoly argument, Vail embraced state and federal regulation and used its de facto recognition of the telecommunications natural monopoly to extend and solidify the Bell systems vertical monopolies controlling local networks and services through the Bell Operating Companies, long distance networks and services through AT&T, equipment manufacturing and distribution through Western Electric, and research and development through Bell Labs.

We can trace the history of AT&T's natural monopoly argument in quotes through time…

> ***1907***: *"One Policy, One System, Universal Service." Theodore Vail*

> ***1927***: *"The fact that the responsibility for such a large part of the entire telephone service of the country rests solely upon this Company and its associated companies… imposes on the management an unusual obligation to the public to see to it that the service shall at all times be adequate, dependable, and satisfactory to the user. Obviously, the only sound policy that will meet these obligations is… to furnish the best possible telephone service at the lowest cost consistent with financial safety." Walter Gifford*

> ***1973***: *"The time has come for a thinking-through of telecommunications in this country, a thinking-through sufficiently objective as to at least admit the possibility that there may be sectors of our economy – and telecommunications one of them – where the nation is better served by modes of cooperation than by modes of competition, by working together rather than by working at odds." John deButts*

The consent agreement ending the Bell System vertical monopoly in 1983 suggested that after a nearly ten year long "thinking-through" the Justice Department, the FCC, and even AT&T itself agreed that the nation is not "better served by modes of cooperation than by modes of competition, by working together rather than working at odds" in all aspects of telecommunications.

Many communities today believe it is in the best interest of their public service, economic development, and competitive marketplace goals to ensure their broadband environment is an open access network allowing any qualifying service provider equal access to public utility network infrastructure. The belief is that while broadband can enhance economic development, competition to provide broadband acts as a catalyst providing significant positive effects. As evidence, they look to the wildfire like adoption of the Internet when access was primarily through dial-up. During the dial-up dominated period of the Internet, just about anyone with a little technical knowledge and a modem bank could function as an

Internet Service Provider (ISP). ISPs aggressively entered the market and their profit motives drove them to pursue a sustainable customer base. Thus, many companies were competing in overlapping markets significantly increasing awareness and adoption.

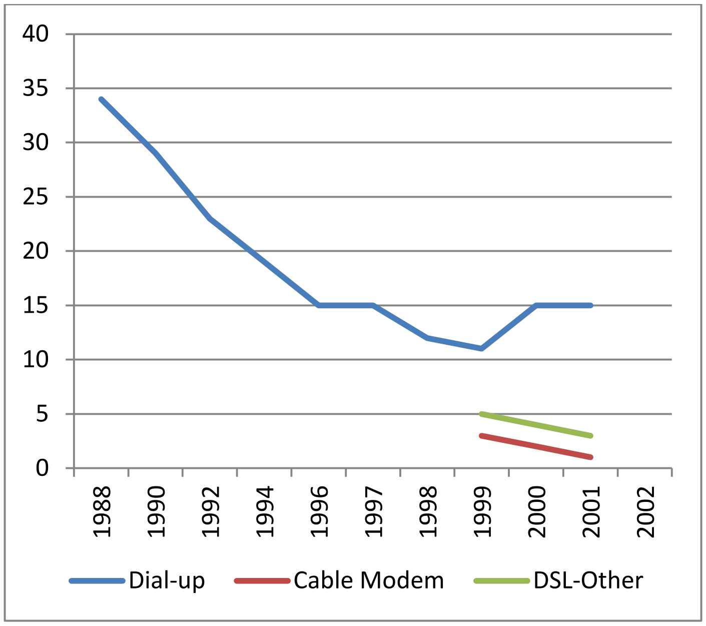

Figure 7: Service Providers per 100,000 Subscribers

As broadband has become more prevalent the number of service providers per 100,000 subscribers has declined. In his article *The Importance of ISPs in the Growth of the Commercial Internet*[14], Mark Cooper compiled the data in "Figure 7: Service Providers per 100,000 Subscribers" from several sources (see p. 29). Cooper goes on to argue that the monopolization of high-speed networks and incumbent anticompetitive practices have had a devastating impact on innovation and free market based price for value controls. He concludes:

Even without intentional anticompetitive behavior, closure of the platform imposes a cost in two ways, by distorting incentives for innovation and undermining institutional options.

First, restricting the range and experimentation and shifting incentives reduces the quality and quantity of innovation and innovators because it shifts the balance between incumbents and disruptive entrants. The hand of incumbents, who shy away from disruptive innovation would be strengthened. Incumbents behave rationally by developing their core competence and seeking structures that reward it. The incentives for innovators are also dampened.

Second, the dominant commercial firms have incentives to expand by commercializing, concentrating, and homogenizing information space. As a result, "[n]oncommercial producers will systematically shift to commercial strategies and [s]mall-scale producers will systematically be bought up by large-scale organizations. Potential sources of disruptive innovation would shrink.

[14] Cooper, Mark (1 July 2002). "The Importance of ISPs in the Growth of the Commercial Internet: Why Reliance on Facility-Based Competition will not Preserve Vibrant Competition and Dynamic Innovation on the High-Speed Internet". Consumer Federation of America Texas Office Public Utility Counsel. Viewed 3 December 2013 at http://www.consumerfed.org/pdfs/ispstudy070102.pdf.

The implication here is that we cannot just wait for the platform to open. Doing nothing in the face of accelerating closure of the communications platform is doing harm. Some of the harm cannot be undone. Rectifying what can be fixed after the fact is immensely time consuming, costly and inevitably more intrusive. (p. 34)

1.1.2.2 Current Regulatory Policy Encourages Private Enterprise Monopolization and Discourages Broadband Investment

Erik Cecil is a telecommunications lawyer working out of Colorado. In a recent email, Cecil wrote:

1. The FCC deregulated broadband, which, were it regulated, would be a utility as it would be subject to the Common Carriage obligations under the 1934 Communications Act. This would mean, among other things, that (a) it would be subject to universal service; (b) providers would be subject to carrier of last resort obligations; (c) there would have to be some form of price control (and we have precedent for forward-looking cost-based pricing, which is the most reasonable approach from a public policy perspective); (d) anyone could attach any device they like to any network - wireless or wireline or cable - rather than being forced into buying device, software and services from the same vertically integrated mega-provider; and (e) would likely do a great deal of good for opening up the worst levels of market concentration we've seen in telecommunications in this country since 1912.

2. Against this backdrop the FCC is attempting piecemeal deregulation of certain segments of the industry while gutting traditional universal service. This is pushed very hard by AT&T (who is quietly abandoning landline), Verizon (who has sold off most of its rural/expensive landline properties) and Comcast, Cox, BrightHouse (who just sold off some of the most desirable spectrum in the country to AT&T and Verizon in exchange for tacit agreement that the AT&T and Verizon would no longer compete in landline markets) all of whom hate paying into a fund they see going primarily to the traditional incumbent landline carriers, who, like so many others, absolutely refuse to deploy fiber optic in the places where it is most needed despite being given enormous sums of taxpayer money.

3. Overall, landline carriers are dying as a result of severely unbalanced regulation and subsidy system that let them harvest enormous direct and indirect subsidies for years without having to invest and upgrade their network plant.

In sum, the current regulatory environment and the FCC's piecemeal deregulatory efforts have created an environment that while it may not be antagonistic to significant private enterprise infrastructure investment it certainly does not encourage it.

1.1.2.3 Wall Street Quarterly Earnings Pressure Discourages Broadband Investment

Incumbent telecommunications providers are under significant pressure from Wall Street to maximize profits from minimal infrastructure investment. Craig Moffet, cable and telephone analyst of Sanford C.

Bernstein, was the top-ranked cable analyst in institutional Investor's annual survey. In 2008 Moffet reviewed Verizon's FiOS investment and called it a $6 billion loss. According to Saul Hansell of the New York Times[15], the main tenets of Mr. Moffett's critique are as follows:

> *Mr. Moffett starts with the premise that the 130-year-old phone network based on copper wire will become extinct.*
>
> *"It is an obsolete technology," he said. "It's not like horses lost share of the transportation market until they stabilized at 40 percent market share."*
>
> *Once the technology was developed in the 1990s to use the existing coaxial cables used for television signals for Internet service and voice calls as well, the writing was on the wall for phone companies, he argued.*
>
> *"In 1996, as soon as you saw that the technology existed for a cable network with vastly higher capacity and vastly lower margin cost to be able to do voice calls over the same network, you would have said the end game is obvious: Cable will win and the telcos will go into bankruptcy. The only question is how long it will take."*
>
> *Lest he be criticized for having a soft spot in his heart for cable companies, Mr. Moffett argues that the cable industry collectively wasted the $100 billion it spent on upgrading its networks.*
>
> *"Cable built a plant that was more expensive than they ever should have built," he said. But now that the cable companies have spent that money, their network is in place to deliver phone service more cheaply than any other alternative, he argues.*
>
> …
>
> *Qwest, which doesn't have a cell phone business to fund any capital expenditures, is the only phone company that has come up with what Mr. Moffett defines as the right answer: do nothing.*
>
> *"Qwest decided there is no return to any of this stuff, so let's run the business for cash," he said.*

What is odd is that Verizon took the hits demanded of it with what it called a $23 billion investment in FiOS but its balance sheets to show the capital expenditure "bump" expected from the new construction. Bruce Kushnick[16] looked at Verizon's capital spending and found "Figure 8: Verizon Wireline Construction Budgets".

---

[15] Hansell, Saul (19 August 2008). "A Bear Speaks: Why Verizon's Pricey FiOS Bet Won't Pay Off." New York Times Bits. http://bits.blogs.nytimes.com/2008/08/19/a-bear-speaks-why-verizons-pricey-fios-bet-wont-pay-off/.

[16] Kushnick, Burce (19 May 2012). "The Great Verizon FiOS Ripoff." Huffington Post. Viewed 11 October 2012 at http://www.huffingtonpost.com/bruce-kushnick/the-great-verizon-fios-ripoff_b_1529287.html.

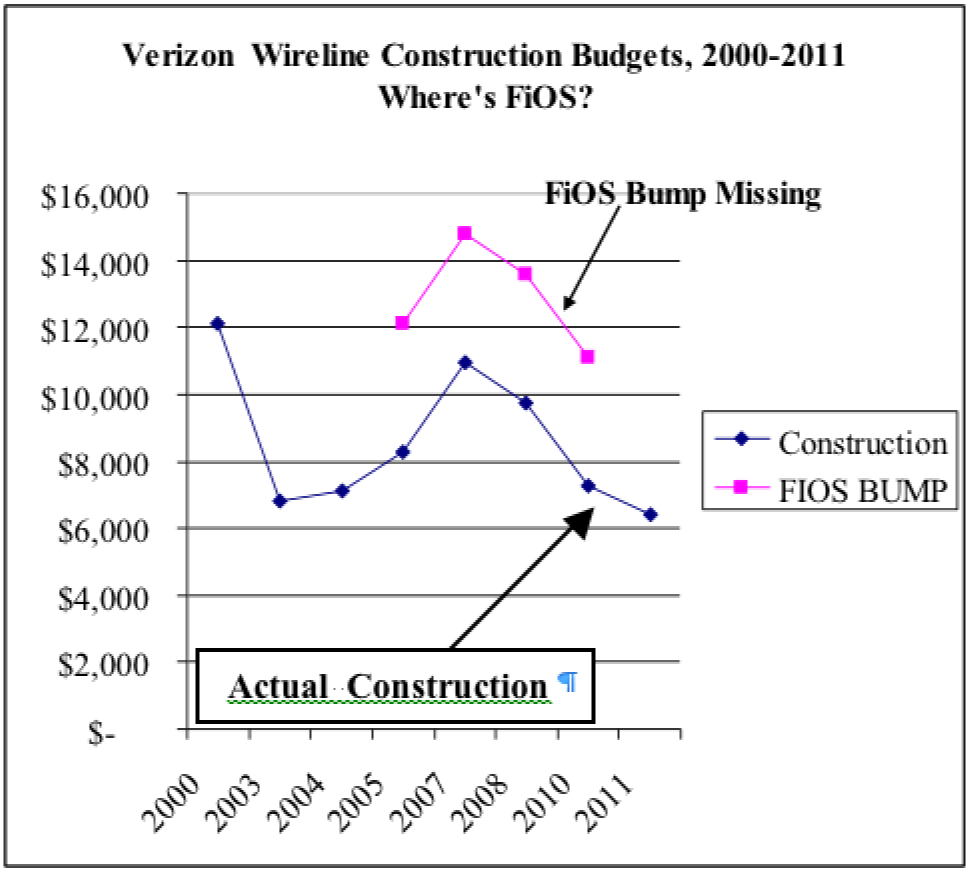

Figure 8: Verizon Wireline Construction Budgets

Actual construction does not show the additional dollars required to implement FiOS. Kushnick continues:

> *Another way to look at it is this: Construction budgets for wireline services historically equal about 20 to 25 percent of revenues. One could reasonably expect that building out a $23 billion network over seven years would lift that percentage to well over 25 percent a year.*
>
> *But it didn't happen. From 2000 to 2004, construction amounted to 22.2 percent of wireline revenues. From 2005 to 2011, it was only 19.7 percent. That's actually a $5.9 billion reduction in construction spending in those latter years, compared to what would have been spent had they just continued spending at the same ratio as during the earlier period.*
>
> *This chart [Figure 9: Verizon Wireline Revenue to Wireline Construction] compares revenue and construction costs for wireline services from 2000 to 2011, in millions of dollars.*

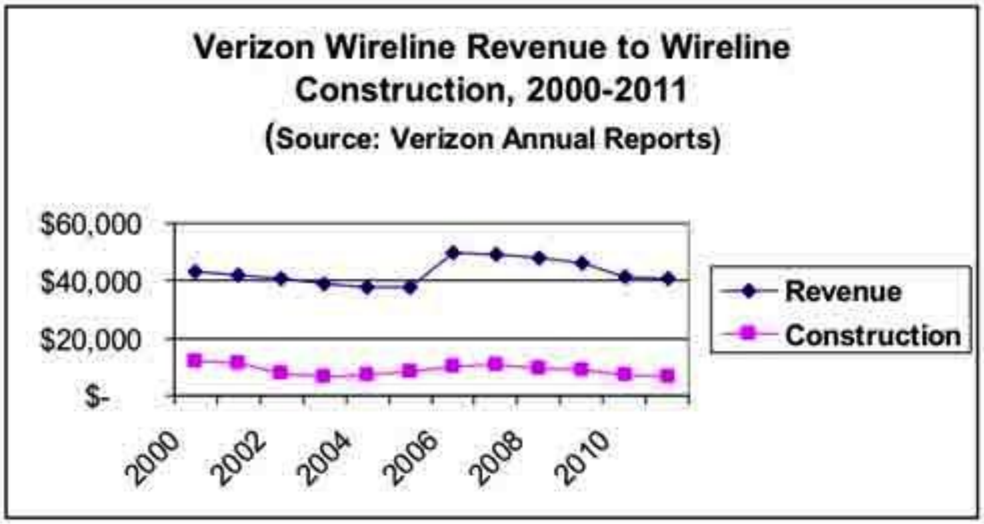

Figure 9: Verizon Wireline Revenue to Wireline Construction

In sum, Verizon's FiOS build – the very build for which Moffett chastised the company – did not reflect on the company's reported capital spending. However, we know Verizon has passed nearly 16 million homes with fiber to the premises. Kushnick argues, "If Verizon did actually spend $23 billion, then it appears to have come at the expense of the traditional maintenance and upgrades of the utility plant…."

Regardless of where or how Verizon paid for FiOS upgrades, their commitment to provide fiber to the premises to all their service areas is over with just 60% of their market built (by selling off much of their rural footprint to Frontier and completing major franchise agreement commitments, Verizon may reach 70% of their market passed)[17]. Verizon may be caving to pressure from Wall Street to reduce its capital expenditures and focus on its less capital intensive wireless business[18].

AT&T has also exhibited a history of caving to pressures to minimize capital expenditures. In 2004 SBC Communications (now AT&T) began a fiber to the premises upgrade called U-Verse. By 2006 U-Verse was being executed via fiber to the node technology to reduce capital expenditures. In 2011 AT&T announced the deployment of U-Verse was effectively over with about 40 to 45% of their market still not upgraded. Karl Bode of Broadband DSL Reports writes, "In short, AT&T claims that despite consistent, healthy profits… they just can't find a financially appealing way to upgrade millions of users, and won't anytime soon…." Bode continues:

> *Forgotten is the fact that AT&T and Verizon… played major roles in passing state laws that ban many of these communities from wiring themselves – even if the tlecos won't. Unlike smaller telcos, it's not that AT&T doesn't have the resources or funds to upgrade*

[17] Bode, Karl (24 January 2012). " If You're Waiting on FiOS, You Could be Waiting a While: 30% of Verizon Customers May Wait Years for Upgrades." Broadband DSL Reports. http://www.dslreports.com/shownews/118039.

[18] See Browning, Jonathan and Cornelius Rahn (6 January 2012). "Verizon Fixed-Line Sale Would Enable Vodafone Combination, Goldman Says." Bloomberg. http://www.bloomberg.com/news/2012-01-06/vodafone-lifted-to-buy-at-goldman-sachs-on-verizon-strength.html.

more users to VDSL or FTTH, they simply lack the long-term patience for serious network reinvestment. Quarterly returns and executive compensation trump network health, customer satisfaction, and product quality.[19]

No major cable company has executed a fiber to the premises build preferring to implement fiber to the node. That leaves the big three telephone companies (Verizon, AT&T, and CenturyLink) and a lot of small companies and communities to find the resources to make this critical 21st century improvement to our nation's broadband infrastructure. As shown here, quarterly earnings pressures have prevented CenturyLink (formerly Qwest) from starting a fiber to the premises upgrade, pushed AT&T to equivocate to a fiber to the node technology and then to stop upgrading altogether, and halted Verizon's FiOS upgrade. Of the more than 150 million addresses in America, 20 million of them can subscribe to fiber and 7 million of them do – and it appears this is where Wall Street is going to stall progress.

1.2 City Goals

Telecommunications history in the US, current regulatory policy, and quarterly earnings pressures and other Wall Street effects lead to a broadband environment characterized by monopoly/duopoly service providers managing bandwidth as a scarce commodity. Resulting that, "…in comparison to their international peers, Americans in major cities such as New York, Los Angeles, and Washington, DC are paying higher prices for slower Internet service."[20] So, why does it matter? It matters a lot because speed and cost determine the opportunities for using the Internet to create jobs and maximize innovations in telemedicine, education, energy conservation, and other areas. Speed and cost are primary drivers when it comes to making government service more accessible through online tools. Speed and cost drive citizens' use or non-use of available online services. Speed and cost have direct impact on the efficiency of telecommunications spending by community anchor institutions. Low speed and high cost lead to inadequate bandwidth for anchor institutions, businesses, and residences causing disparity in availability and access. This disparity affects economic development and quality of life. To quote from the National Broadband Plan[21]:

Not having access to broadband applications limits an individual's ability to participate in 21st century American life. Health care, education and other important aspects of American life are online. What's more, government services and democratic participation are shifting to digital platforms.

The Louisville Metro Government has recognized a need to change their broadband status quo. The RFI indicates LMG's primary goal is to increase penetration of affordable broadband service to foster innovation, drive job creation, and stimulate economic growth.

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[19] Bode, Karl (9 February 2012). "AT&T: The U-Verse Build is Over: Like FiOS, if You didn't get it already, you probably won't." Broadband DSL Reports. http://www.dslreports.com/shownews/ATT-The-UVerse-Build-is-Over-118297.

[20] Hussain, Hibah, Daniel Kehl, Patrick Lucey, and Nick Russo (2013). "The Cost of Connectivity 2013". The New America Foundation; Washington, DC. Viewed 18 January 2014 at http://newamerica.net/sites/newamerica.net/files/policydocs/Cost_of_Connectivity_2013_Data_Release.pdf.

[21] The National Broadband Plan can be found at http://www.broadband.gov/plan/2-goals-for-a-high-performance-america/

To achieve LMG's primary goal of increasing penetration of affordable broadband service to foster innovation, drive job creation, and stimulate economic growth, LMG has devised three target objectives or subordinate goals as follows:

- Goal 1: Create a world-leading gigabit-capable network in targeted commercial corridors, as well as in residential areas with demonstrated demand, to foster innovation, drive job creation, and stimulate economic growth.
- Goal 2: Provide free or heavily-discounted 100 MB (minimum) internet service over a wired or wireless network to underserved and disadvantaged residential areas across Louisville.
- Goal 3: Deliver gigabit internet service at prices comparable to other gigabit fiber communities across the nation.

Additionally, the RFI clarifies that LMG intends to be an infrastructure and policy partner only and does not intend to act as a retail service provider or network operator.

1.2.1 World-Leading Gigabit-Capable Network

A world-leading gigabit-capable network contributes to economic development, public safety, infrastructure development and maintenance, building a sense of community, education, healthcare, government services and efficiencies, and other public goals.

1.2.1.1 Economic Development

In 19th century America, a railroad spur and stop could make or break a community's economy. In the 20th century, Interstate exits became a critical piece of transportation infrastructure needed to support a local economy. In the 21st century, critical transportation infrastructure is as much about moving bits and bytes as bricks and mortar. Economic development has become dependent on access to reliable bandwidth of sufficient capacity to attract and support the knowledge workers of the 21st century.

Communities' historic reliance on private telecommunications companies with near monopoly control of the network environment is no longer an adequate solution to meet the needs of 21st century economic development. In order to support the growth of good paying jobs and a stable tax base communities must take control of their telecommunications destiny.

Deployment of a public-private partnership open access fiber to the premises network allows a community to control its telecommunications destiny. Deploying fiber all the way to the premises designs the future into the network. Businesses and residents can be confident that network capacity will be available to meet their growing data needs. An open access network ensures residents and businesses will receive the benefits of multiple companies competing to provide them service. This competition spurs innovation and ensures economic efficiencies that simply cannot be replicated in a wholly owned and operated system.

Part of what economic development is about is creating jobs. Deploying and supporting municipal telecommunications networks directly create new jobs. However, more valuable than the direct jobs created by the implementation and support of the network is the extraordinary foundation for other new job creation true choice of true broadband offers.

Broadband enabled technologies unquestionably enhance economic opportunity. In May of 2012 David Salway, in an article for About.com suggests, “There is little debate that increasing broadband access spurs economic development, but can this be quantified?”[22] Salway then compiles a list of some of the leading research completed on the economic effects of broadband. Paraphrasing Salway’s list:

- Robert Atkinson of The Information Technology and Innovation Foundation[23] claims in an Associated Press/USA Today article by Joelle Tessler that, “a $10 billion investment in broadband would produce as many as 498,000 new jobs.”[24]
- In “The Effects of Broadband Deployment on Output and Employment: A Cross-Sectional Analysis of U.S. Data,” Robert Crandall, William Lehr, and Robert Litan of the Brookings Institute, the authors determine that for every one percentage point increase in broadband penetration in a state, employment is projected to increase by 0.2 to 0.3 percent per year.[25]
- In “Broadband Infrastructure and Economic Growth,” Nina Czernich, et. al. find that “a 10 percentage point increase in broadband penetration raises annual per-capita growth by 0.9-1.5 percentage points.”[26]
- Between 1998-2002 communities that gained access to broadband service experienced an employment growth increase of 1% to 1.4%, a business establishment increase of 0.5% to 1.2%, and a rental value increase of 6%.
- Kristen Van Gaasbeck, et. al. found in their “Economic Effects of Increased Broadband Use in California Research Report” that “this analysis paints a clear picture of how increased broadband use (and the migration from dial-up to broadband) affects employment and payroll in California and a select group of its regions – the direction of the effect is always positive and the magnitude depends on the size of the shift in the percentage of the adult population using a broadband Internet connection. Even a small increase in broadband use could generate a substantial cumulative gain over the next 10 years compared to what could be expected under business as usual conditions.”
- For every $1 million granted for broadband development, 15 jobs would be created.

1.2.1.2 Public Safety

Ubiquitous deployment of true broadband can support public safety. Police and private security companies can deploy high definition and heat sensitive security cameras for remote monitoring of

[22] Salway, David (May 2012). “Broadband as an Economic Driver.” About.Com. http://broadband.about.com/od/economicdevelopment/a/Broadband-As-An-Economic-Driver.htm.
[23] http://www.itif.org/
[24] Tessler, Joelle (6 February 2009). “Broadband Funding in Stimulus Plan Sparks Debate.” USA Today. http://www.usatoday.com/tech/news/2009-02-06-broadband-funding_N.htm.
[25] Crandall, Robert W., William Lehr, and Robert Litan (July 2007). “The Effects of Broadband Deployment on Output and Employment: A Cross-Sectional Analysis of U.S. Data.” The Brookings Institute Issues in Economic Policy; Washington, DC. http://www.brookings.edu/views/papers/crandall/200706litan.pdf. http://www.brookings.edu/~/media/research/files/papers/2007/6/labor%20crandall/06labor_crandall.pdf.
[26] Czernich, Nina, Oliver Falck, Tobias Kretschmer, and Ludger Woessman (December 2009). “Broadband Infrastructure and Economic Growth.” CESIFO Working Paper. http://www.cesifo.de/pls/guestci/download/CESifo%20Working%20Papers%202009/CESifo%20Working%20Papers%20December%202009/cesifo1_wp2861.pdf.

sensitive areas. Fire departments can take advantage of data provided via intelligent alarm systems. Police departments can more effectively use systems like Shot Spotter to detect and deter violent crime.

The FCC has this to say about broadband and public safety and homeland security: "Broadband technology is particularly critical to public safety because it can provide enhanced situational awareness from first responders in emergency situations. Through broadband use, public safety entities can access medical records, site information and other video and data information useful for emergency responses. Broadband will also improve the nation's current 9-1-1 system by establishing the foundation for the transmission of voice, data or video to Public Safety Answering Points (PSAPs) during emergency phone calls."[27]

In February of 2012, Congress enacted "The Middle Class Tax Relief and Job Creation Act of 2012." The Act included a provision to create a nationwide interoperable broadband network that will help police, firefighters, emergency medical professionals, and other public safety officials stay safe and help them do their jobs. The law establishes the "First Responders Network Authority", or FirstNet, within the Department of Commerce's National Telecommunications and Information Administration. The network will be based on the 700 mhz spectrum set aside for public safety. FirstNet will hold the spectrum license for the network and is charged with taking all actions necessary to build, deploy, and operate the network. The Act provides $7 billion in funding towards deployment of the network and another $135 million for a new state and local implementation grant program.[28]

In a panel discussion at Fire-Rescue International in August of 2012, Chief R. David Paulison, former U.S. Fire Administrator highlighted the essentiality of broadband for high speed data and quality video transmission.

> *'What it's really going to give us is data where we simply couldn't access it before' which will increase situational awareness…*
>
> *Paulison recalled a fire he was watching on television news, which allowed him to see information that the incident commander could not – and that firefighters on scene were about to make a trench cut in the wrong place. He called in, and they changed tactics as a result of his input. With broadband, the IC could have seen such video firsthand.*
>
> *Paulison added examples for using broadband, such as for biometric firefighter monitoring, for transmission of building layouts and information about hazardous materials within, and for conference calling with subject matter experts and allowing them to see what you are seeing on the scene.*
>
> *He also spoke of the potential for EMS – for responders to access patient records on scene, and transmit real-time video and vital signs of patients back to doctors and*

[27] From FCC Public Safety and Homeland Security Bureau viewed 2 Oct 2012 at http://transition.fcc.gov/pshs/broadband.html.
[28] See http://www.ntia.doc.gov/category/public-safety for more information.

specialists, with the possibility of making faster treatment plans and sometimes avoiding the need to wait for doctors or surgeons to make assessments on scene.

'These are the things that I see in the future,' Paulison said. 'This folks, to me, is the future of the fire service… I think it's time for us to get on board and bring ourselves into the twenty-first century.'[29]

Fire and EMS personnel are not the only public safety beneficiaries of broadband deployments. The Utah Broadband Project writes:

Broadband also puts information instantly in the hands of law enforcement, including photos and fingerprints of suspects, and allows monitoring of both police and suspects in high-risk situations. Broadband can also enable more timely assistance from citizens who can quickly send text, photos or video from mobile devices to law enforcement.

Law enforcement must constantly access multiple large databases such as Department of Licensing, Department of Corrections and local jails. Broadband-enabled searches are faster, putting important information at the scene in a timely manner. And in some circumstances broadband can be an effective communication tool when traditional tools such as radios or cell phones don't work.[30]

Of course, many public safety needs require mobility. Some may argue wireless is the only reasonable solution. OHIvey agrees that wireless broadband is a critical component of public safety broadband, but the sooner that wireless signal can be placed on a piece of fiber, the better and more reliable the service will be.

1.2.1.2.1 Enhanced Video Surveillance and Security

Broadband allows a range of video surveillance applications. Using a digital camera, either a wired or wireless Internet Protocol ("IP") network, and a back-end monitoring system, communities can remotely monitor people, buildings, and traffic to enhance public safety and reduce crime. Outdoor Wi-Fi mesh networks supported by abundantly available fiber connections are transforming the field of video surveillance by offering easy-to-install, highly-scalable solutions.

Fiber is needed for high-quality video surveillance. Depending on bandwidth, surveillance cameras can provide information ranging from simple black-and-white still images to high-resolution, 30-frames-per-second color video. Surveillance cameras can be hardwired into the network via Ethernet, directly connected through Ethernet to a collocated Wi-Fi base station, or deployed as Wi-Fi clients. Bandwidth requirements will vary, depending on the application and the quality of the video. Inadequate bandwidth could result in unstable and insecure signals.

[29] Caspi, Heather (2 August 2012). "Experts Present Update on Broadband for Public Safety." Firehouse. http://www.firehouse.com/news/10754689/experts-present-update-on-broadband-for-public-safety.
[30] From http://blog.broadband.utah.gov/impact/public-safety/.

Video surveillance is attractive because it enables a low-cost solution to monitor public spaces without adding any more feet on the street. A single employee can simultaneously observe multiple cameras and deploy personnel where they are most needed. Surveillance cameras can be used to detect trespassers, loitering, illegal parking, dumping, and theft, and help with crowd control. These services have been deployed on roads at industrial construction sites, in crowded public spaces such as airports, train stations, and public festivals, and in remote open areas, such as parks.

Potential applications include:

- Remote monitoring of construction sites after hours to prevent vandalism, trespassing and theft.
- In-vehicle cameras to enable security officers to identify where they are most needed, efficiently deploy staff, and be prepared to act appropriately when they arrive on the scene.
- Forensic evidence to expedite legal proceedings to apprehend criminals.
- Video monitoring to ensure compliance with safety procedures (thereby reducing liability).
- Remote monitoring of vehicle and equipment "health" to ensure that maintenance is provided as needed.
- Inventory tracking to facilitate just-in-time equipment transfers and detect theft if it occurs.
- Internet access for employees to expedite paperwork and remote communications.
- Virtual neighborhood watch to cost-effectively monitor and deter crime.
- Crowd control and observation at large public gatherings.
- Observation of forested areas during times of high fire danger, to allow rapid detection and response.
- Real-time communication between emergency medical technicians and emergency room doctors to help prepare hospital staff for new arrivals and to allow hospital staff to recommend treatment during transport.

Many municipalities are already employing surveillance cameras for these purposes. Of particular note, Chicago has used a combination of unified fiber and wireless mesh networking to create a "virtual shield" around the city. The network covers the entire city with thousands of real-time, high-quality video access points. These cameras (which cover both private and public sector establishments) are combined into a single unified system, with bandwidth requirements that would exceed the capabilities of a simple wireless network. The Chicago system is state-of-the-art, featuring some cameras that will automatically film in the direction of gunshot sounds before dialing 911. The network can capture, monitor, and index footage for safety and forensic applications. The system "entailed building a unified fiber network throughout the downtown Chicago area, deploying a critical wireless infrastructure to offer flexibility as required, installing hundreds of new surveillance cameras, linking thousands of preexisting cameras to the network, and creating a fully redundant backend system to monitor the video, store the images and allow for business continuity and disaster recovery applications." The

results have been dramatic. Before the system was installed, from January to May 2003, there were 24 murders in the city's District 11. In 2005, there were only four murders during the same period—an 83 percent decline.

Other municipalities have used more modest networks to enhance public safety, despite a shortage of police officers. In Savannah, Georgia, surveillance cameras monitor the City's 22 historic squares and "increase[e] police visibility in key problem areas" around the city. Cameras also supplement security by providing "eyes in the sky" during large public gatherings, such as the City's Saint Patrick's Day Festival. Cameras have helped improve the efficiency of the limited police force, allowing officers to locate problem areas, witness crimes in progress, reduce response time, and enable access to criminal and DMV records in the field.

The City of Laguna Beach, California has deployed a state-of-the-art wireless video network for a variety of applications around a 20-square-mile area that encircles the city. Solar-powered cameras are stationed at areas with high fire risk and monitored by park rangers to allow early detection of—and rapid response to—wildfires. The same network can also be used to monitor wildlife activity. The surveillance system supplements a streamlined staff during the winter by providing virtual lifeguards focused on the most dangerous locations, allowing lifeguards to spot—and approach—swimmers as they enter. The same network provides webcast coverage of local events, such as historical society meetings and the Patriot's Day Parade. The city plans to expand the network to allow for automated utility meter reading and mobile city operations, whereby city staff can submit field reports remotely.

1.2.1.3 Infrastructure Development and Maintenance

Public broadband infrastructure adds a new infrastructure development and maintenance opportunity to local governments. But more than that, public broadband infrastructure can be used to help improve the efficient use and maintenance of existing public works. Broadband enabled cameras can be used to monitor remote public works sites, lights and irrigation systems can be operated based on information gathered via broadband, traffic can be more effectively managed, power systems monitored and managed, water systems controlled, and so on.

Broadband can relieve traffic congestion by allowing cities to coordinate traffic lights to improve flow. A 2005 U.S. Department of Transportation survey concluded that poor traffic signal timing is responsible for 10 percent of all traffic delay – roughly 300 million vehicle hours annually.[31] By using a broadband network to coordinate traffic signals, a municipality can expect to:

- Reduce congestion by allowing for the smooth flow of traffic at a constant speed.
- Improve mobility and decrease capital costs for intersection improvements by increasing the traffic handling capacity of intersections.
- Improve air quality and increase fuel efficiency by reducing vehicle stops, starts, and idling.

These benefits require an intelligent transportation system, or ITS. ITS features are enhanced when supported by the true broadband offered only by fiber.

Austin, Texas implemented an ITS in 2005 and 2006. The city reports more than $40 million in annual savings for its residents including:

[31] U.S. DOT (2005). "Intelligent Transportation systems for Traffic Signal Control." Retrieved 2 October 2012 from http://ntl.bts.gov/lib/jpodocs/brochure/14321_files/a1019-tsc_digital_n3.pdf.

- $35 million annually in delay reduction (a 9.8% reduction in travel time along all arterials reducing traffic delay by 2.342 million hours).
- $3 million annually in reduced stopping (28% reduction in the number of stops per intersection for a total of 195.1 million fewer stops each year).
- $2.6 million in fuel savings (3.5% or nearly 1.3 million gallons of gasoline in annual fuel consumption reductions)[32]

Of course broadband can help with complex systems like traffic management, power monitoring, and water flow. But what about simple infrastructure – like street lights?

The city of Chattanooga, Tennessee is using their municipally owned network to significantly improve their street lighting. First, the city has installed new LED street lamps. The change to LEDs is expected to cut energy use by 70%. However, the city decided to take their streetlights seriously and to install a Global Green Lighting system expected to save the city 85% or nearly $2.7 million per year. The system, managed using Chattanooga's broadband system, provides the ability to control each light's output to tailor the level of light specifically to each lamp, the environment, the time of night, and even what might be happening on the ground. Furthermore, when a light is not working, it can self-diagnose and send a message to maintenance describing the problem it is having and what is needed to fix it. As an added bonus, there is no need for manual meter reading because energy usage is reported through the network.

The community sees public safety benefits to the new lighting as well. Police can control the brightness of the lights when they are chasing suspects in parks, alleys, or other areas where lighting is typically dim. David Crockett, director of the city's office of sustainability says, "A policeman can sit in his car and double the intensity or turn the lights off if there is was a need to cover a SWAT team."[33]

Other infrastructure can also be supported through ubiquitous broadband deployments – whether it is keeping an eye on remote sites to protect them from graffiti, remotely checking the park for occupants before turning off the lights, allowing residents to report potholes via smart-phone app, or any other innovation – a municipal fiber network helps make it better.

1.2.1.4 Building a Sense of Community

Exceptional quality and capacity broadband driven to reasonable prices by real competition enables professionals to work around the world from their home office. But it is also having another interesting impact. Tim Harford writes[34]:

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[32] See Columbia Telecommunications Corporation (September 2009). "Benefits Beyond the Balance Sheet: Quantifying the Business Case for Fiber-to-the-Premises in Seattle." http://www.seattle.gov/broadband/docs/SeattleFTTNBenefits_091109.pdf for more information.

[33] See Gonzalez, Lisa (22 May 2012). "Green Lighting In Chattanooga – Savings, Safety and Jobs." Community Broadband Networks. http://muninetworks.org/tags-263.

[34] Harford, Tim (18 January 2008). "How Email Brings You Closer to the Guy in the Next Cubicle." Wired; Issue 16 Volume 2. http://www.wired.com/culture/lifestyle/magazine/16-02/st_essay.

> *In a study published in the American Economic Review, researchers examined 4,000 US-based commercial innovations and found that more than half came from just three areas: California, New York/New Jersey, and Massachusetts. Almost half of all US pharmaceutical innovations were invented in New Jersey, a state with less than 3 percent of the nation's population.*
>
> *In theory, technology should allow new-economy firms to prosper as easily in Nebraska as in Silicon Valley. But far from killing distance, it has made proximity matter more than ever.*

Harford suggests this may be because, as Harvard economist Ed Glaeser argues, "technology and face-to-face interactions are complements like salt and pepper, rather than substitutes like butter and margarine. Paradoxically, your cell phone, email, and Facebook networks are making it more attractive to meet people in the flesh." In other words, our electronic lives enrich and enhance our personal lives and strengthen our communities.

Relevant to this point is the interesting fact Geoff Daily writes about in his AppRising article[35] that in Vasteras, Sweden (one of the first and largest open access fiber to the premises networks in the world):

> *Before this community fiber network was put in place, more than 80% of the traffic on local networks was outbound, pulling in and sending out information over the world wide web.*
>
> *After the fiber network came into being? That ratio basically flipped as now more than 80% of the bandwidth being consumed is for moving data around within the Vasteras network, so neighbors talking to neighbors rather than users pulling in data from all over the Internet.*
>
> *It should be noted that just because the percentage dropped, doesn't mean people on the network are consuming outlying Internet content less. Instead, it's a sign of just how massively demand for bandwidth in-network has grown, literally more than a thousandfold."*

While nay-sayers suggest the digital age is damaging human relations, the evidence shows otherwise. True choice of true broadband appears to actually increase local interaction and build a sense of community.

1.2.1.5 Education

No amount of technology can ever replace the powerful impact of a teacher interacting face to face with a student one on one or in reasonably sized classrooms. But even the best of teachers can augment the education they offer with online resources. Furthermore, true broadband can bring critical training

[35] Daily, Geoff (28 January 2008). "Internet Reinforces Local Bonds." AppRising. Viewed 1 March 2012 at http://www.app-rising.com/2008/01/internet_reinforces_local_bond.html.

resources and those in need of the training together more often and in more ways than can be imagined.

Broadband enables educational applications for students, parents, and professionals. A 2009 survey conducted in Colorado demonstrated the need for broadband for currently available services:

K-12 Bandwidth Application and Software Analysis

Model Basis
250 Students; 12 Teacher/Admin; 260 Computers; 12 VoIP Phones; 10/100 Ethernet LAN
Dynamic Use - 260 Computer Users using one or more Applications simultaneously across LAN and Internet

Application *	Per User*	One T-1 (1.5 Mbps)	Two T-1s (3 Mbps)	Four T-1s (6 Mbps)	10 Mbps Ethernet	20 Mbps Ethernet
VoIP	50 kbps	🟩	🟩	🟩	🟩	🟩
Email and Web Browsing	50 kbps	🟩	🟩	🟩	🟩	🟩
Audio Streaming (MP3)	100 kbps	🟨	🟩	🟩	🟩	🟩
School Portal	100 kbps	🟨	🟨	🟩	🟩	🟩
Student Created Content	150 kbps	🟥	🟨	🟩	🟩	🟩
Online Learning	150 kbps	🟥	🟥	🟨	🟩	🟩
Virtual Field Trips	150 kbps	🟥	🟥	🟨	🟩	🟩
Web/School 2.0 Tools	250 kbps	🟥	🟥	🟥	🟩	🟩
Online Assessment	250 kbps	🟥	🟥	🟥	🟩	🟩
TV-Quality Streaming Video (320 x 240)	250 kbps	🟥	🟥	🟥	🟩	🟩
Interactive Video at a Desktop Standard Definition Good Quality	250 kbps	🟥	🟥	🟥	🟨	🟩
DVD Quality Streaming Video (640 x 480)	1040 kbps	🟥	🟥	🟥	🟨	🟩
1/2 HD Quality Streaming Video (1024 x 720)	4977kbps	🟥	🟥	🟥	🟥	🟩
H.264 HD (1080 P) Video Conference	6000 kbps	🟥	🟥	🟥	🟥	🟨
Full HD Quality - Streaming Video (1920 x 1080)	13998 kbps	🟥	🟥	🟥	🟥	🟨

KEY
🟩 - Full Functionality
🟨 - Problematic
🟥 - Unable to utilize with concurrent users

Figure 10: Broadband Use for Current K-12 Applications

Of course, as technology continues to develop, the need for broadband to support education will become ever greater.

The nation's schools suffer from inadequate Internet access and IT training. For most, access is too slow with insufficient bandwidth to allow creative and expansive online learning, such as video conferencing or collaborative work. Schools with constrained bandwidth have limited options for classroom use of IT applications such as streaming video. The Benton Foundation explains:

> *Distance learning over broadband is a distant dream. Online curricula is offline. Teachers are insufficiently trained to use technology in their classrooms, so that whatever technology is available to them languishes. Students are taught the basic 3 Rs,*

as required by the No Child Left Behind Act, but not the digital skills that will enable them to translate those 3 Rs into success in today's Information Age.[36]

Many schools are using the Internet to expand course offerings. For instance, in Greenville, South Carolina, students are enrolling in an online Latin course taught by a teacher at another district school. Elsewhere, students can use the Internet to take higher level or better-quality courses than those available at their home schools. The Internet helps break down the walls of the classroom, allowing students to participate in remote classes and in virtual field trips. Students are going online and "touring the Smithsonian National Air and Space Museum, experiencing a tribal dance in Africa, or scouring the depths of the Pacific Ocean in a submarine." Users are exploring the digital archives at the Library of Congress and collaborating with students, professors, and government officials in other states and around the world.[37]

According to the "America's Digital Schools 2008" 37% of school districts anticipate a problem obtaining sufficient bandwidth and the majority have implemented policies to conserve bandwidth by limiting student Internet use[38]. Nonetheless, Internet proficiency is assumed at the college level, leaving many children at an educational disadvantage.

Outside of traditional classroom environments, broadband enables adult continuing education and professional development by bringing instructors and students together without travel costs.

1.2.1.6 Reduced Cost and Enhanced Quality of Healthcare

The U.S. healthcare system is expensive, overburdened, and inefficient. In 2006, national healthcare costs grew 6.7 percent to $2.1 trillion, or $7,026 per person, and accounted for 16 percent of gross domestic product (GDP). Similar growth is projected to continue until 2017, at which point healthcare will account for nearly 20 percent of GDP. Some of this expense can be attributed to the inappropriate reliance on costly hospital emergency rooms, which are often sought after traditional office hours or in communities with a shortage of physicians. In fact, over half (55 percent) of the 114 million emergency room visits Americans make each year are for non-emergencies, accounting for $31 billion annually, or $300 per American household. Broadband technology can dramatically reduce these expenses by providing the tools to remotely monitor patients, allow collaboration between medical professionals, facilitate the transfer of medical data and images, and increase access to emergency services in remote areas. By one estimate, these services can lead to savings of $165 billion per year. "Always-on broadband" is "essential" for some of these applications and greatly improves others that "depend on uninterrupted real-time transmission."

[36] Rintels, Jonathan (2008). "An Action Plan for America: Using Technology and Innovation to Address our Nation's Critical Challenges: A Report for the new Administration from the Benton Foundation." Benton Foundation. http://benton.org/sites/benton.org/files/Benton_Foundation_Action_Plan.pdf.

[37] Rintels, Jonathan (2008). "An Action Plan for America: Using Technology and Innovation to Address our Nation's Critical Challenges: A Report for the new Administration from the Benton Foundation." Benton Foundation. http://benton.org/sites/benton.org/files/Benton_Foundation_Action_Plan.pdf.

[38] Greaves, Thomas W. and Jeanne Hayes (2008). "America's Digital Schools 2008: The Six Trends to Watch." The Greaves Group; The Hayes Connection.

1.2.1.6.1 Medical Information

Broadband can allow users to access medical information online, avoiding costly trips to medical professionals. Approximately 20,000 health-related websites provide information to the more than three-quarters of online Americans who access medical information over the Internet. More than 10 percent of broadband users use the Internet for this purpose on a given day. Broadband users can also avoid scheduling (and driving) to multiple appointments by using the Internet to get a second opinion based on their medical records or by exchanging e-mails with their doctors. Notably, Kaiser Permanente reduced appointments with primary care physicians by 7 percent to 10 percent by allowing its enrollees to e-mail questions to their doctor through a secure messaging system. Thirty-seven percent of Kentucky broadband users report that access to online information has saved them an average of 4.2 unnecessary trips for medical care in a single year.

1.2.1.6.2 Remote Health Monitoring

Telehealth holds particular promise for remote monitoring of chronic conditions. Nearly half of Americans (45 percent or 130 million people) suffer from at least one chronic condition, such as arthritis, asthma, cancer, depression, diabetes, heart disease, and obesity. Combined, treatment of these conditions accounts for 75 percent of healthcare spending—$1.5 trillion annually. Despite this enormous expense, most Americans with chronic conditions suffer from inadequate treatment. For instance, according to the National Center for Policy Analysis, less than one-fourth of patients with high blood pressure control it adequately. Twenty percent of patients with Type-1 diabetes fail to see a doctor annually, with 40 percent of diabetics failing to regularly monitor their blood sugar level or receive recommended annual retinal exams.

Through remote health monitoring, tens of millions of Americans can manage and address their chronic illnesses at dramatically lower cost. In fact, both the Benton Foundation and the University of Texas estimate that remote monitoring could lower hospital, drug, and outpatient costs by 30 percent, reducing the length of hospital stays from 14.8 days to 10.9 days, office visits by 10 percent, home visits by 65 percent, emergency room visits by 40 percent, and hospital admissions by 63 percent.

Remote-monitoring applications are incredibly varied. Patients with chronic obstructive pulmonary disease can improve lung function with the use an inhaler and monitor airflow to and from their lungs with a spirometer, lowering hospital readmissions to 49 percent as compared to 67 percent for patients lacking home monitoring. Similarly, remote monitoring of a group of congestive heart failure patients in one study cut rehospitalizations in half over a six-month period. Diabetics in Pennsylvania using home monitoring systems for their glucose levels were able to reduce hospitalization costs by more than 60 percent from a control group with traditional in-person nurse visits. The Veterans Administration reports similar savings from its home-monitoring system, which has reduced emergency room visits by 40 percent and hospital admissions by 63 percent. As discussed later, remote monitoring holds particular promise for the elderly, by allowing them to defer or avoid institutionalization, thereby enhancing quality of life and reducing medical costs.

1.2.1.6.3 Lowered Medical Transportation Costs

Broadband can also reduce transportation costs between medical facilities by allowing doctors to remotely monitor patients and collaborate with one another. As the Center for Information Technology Leadership ("CITL") notes, widespread adoption of telehealth technologies can "bring the collective wisdom of the entire healthcare system to any patient, anywhere, any time," allowing "quantum leaps in the efficiency of the healthcare system." These efficiency gains are accompanied by dramatic cost savings.

In fact, CITL estimates that telehealth technologies can prevent:

- 39 percent (850,000) of transports between emergency departments, with an annual savings of $537 million.
- 43 percent (40,000) of transports from correctional facilities to emergency departments and 79 percent (543,000) of transports from correctional facilities to physician office visits, with an annual savings of $280 million.
- 14 percent (387,000) of transports from nursing facilities to emergency departments and 68 percent (6.87 million) of transports from nursing facilities to physician office visits, with an annual savings of $806 million.

It should be noted that the costs and benefits associated with avoided medical transport are not necessarily borne by the same people. The underlying costs of installing the telehealth technology are borne by the physician office or hospital. Savings associated with avoided transports because of this technology, however, accrue to the payer, which (with the exception of correctional institutions), is likely the patient, the state, or insurance provider. Moreover, these savings will only accrue if both institutions (e.g., the correctional facility and hospital) have adequate bandwidth.

1.2.1.6.4 Improved Medical Efficiencies

Broadband can help cut costs by improving efficiency in a number of ways. In hospitals, remote monitoring with high-resolution video allows a single doctor to simultaneously observe and treat multiple patients. The American Consumer Institute reports that this application reduced ICU deaths by 50 percent at Johns Hopkins. The potential benefits of telemedicine outside a single institution are even greater. Because the current medical system is fragmented, doctors seldom have comprehensive information about a patient's medical history, leading to costly and invasive duplicate procedures. This disjointed system means that "[p]atients may be treated at multiple locations by multiple doctors who keep multiple paper records and fill out multiple paper forms seeking reimbursement from multiple insurance carriers." By creating a universal repository for medical records, caregivers can coordinate treatment, easily provide second opinions, streamline billing, and avoid duplicative procedures. Online access to medical records could help doctors avoid such inefficiencies, with savings totaling $81 billion annually—or $670 per household. Of course, these savings will require a significant up-front investment from medical professionals who will have to upload medical histories and transition to electronic record keeping.

1.2.1.7 Enhanced Government Services and Government Efficiencies

Broadband can make myriad services available to improve government efficiency and performance. While many of these individual services can be performed through a wireless network, these and the wide array of other services require a fiber backhaul to provide sufficient speed and capacity.

Examples of innovative services that could be provided over a broadband fiber-optic network include expanded monitoring and control of the community's water systems. Human Services could utilize broadband to extend educational and vocational training programs into served communities. Video-based teleconferencing capabilities could improve the efficiency of government employees' daily work. Teleconferencing could reduce need for travel throughout the community and permit employees to work from home.

Broadband can be used to improve emergency medical response, too. By accessing real-time video while patients are en route, emergency room doctors can ensure that appropriate treatment is ready when patients arrive. Such in-field assessment (enabled by wireless connectivity supported through a robust fiber optic backbone network) expedites treatment and gives doctors more time to consider an appropriate response for critically ill patients. If necessary, staff can consult by teleconference with multiple doctors before patients arrive to better inform the diagnosis. In field-diagnosis also allows emergency room doctors to identify (and re-route) non-emergencies before patients arrive at the hospital. This helps avoid unnecessary and costly emergency room visits, ensuring that medical staff is available to assist with true emergencies. Broadband also improves diagnoses en route by providing electronic access to patient information. This could allow staff to process vital information regarding the patient's condition to expedite treatment upon arrival. Moreover, by alerting emergency medical technicians of drug reactions, allergies, and medical history, the EMTs can improve patient care and safety. Finally, traffic management can improve travel time, speeding access to appropriate medical care. Tucson, Arizona is already realizing many of these medical benefits in the nation's first video-based Emergency Medical Services telemedicine system.

Broadband access also improves the performance and efficiency of municipal employees, while reducing overall staffing needs, by allowing a virtual presence. Surveillance cameras allow remote monitoring of wildlife, high-fire areas, and high-crime areas. Similarly, automated utility meter readings and real-time management of networked parking meters can reduce staffing requirements while increasing revenue. Broadband access improves emergency response and allows employees to spend more time in the community by enabling them to access information and file paperwork from the field. This also facilitates simultaneous filing for multiple departments, such as building inspections and building permits. Broadband also allows the City to track its vehicles and staff, reducing response time when problems occur and improving safety for City staff. For instance, GPS can improve safety by tracking a firefighter's location within a building during an emergency. Mobile voice-over-IP phones can further reduce costs.

1.2.1.8 Other Public Goals

Improving broadband capacity, reliability, and affordability can:

- Enable home officing – reducing traffic congestion and fuel consumption;
- Extend aging Americans ability to stay in their homes through remote health monitoring and other services;
- Open new service areas only imagined today.

1.2.2 Free or Heavily-Discounted Service for Underserved and Disadvantaged

Data show that certain race and income classes have far less access to broadband in America. This is simply unacceptable. Access to the information and opportunities available through true broadband should be equally available to all residents.

Unfortunately, the exigencies of incumbent telecommunications providers' business plans drive them to "cherry pick" those areas where they are more likely to generate the highest revenues. This practice serves to widen the digital divide. In some cases, cities have been able to effectively use franchise agreements to force incumbents to deploy in underserved areas but it is typically done at perceived sacrifice on behalf of the provider.

A municipal deployment of open access fiber to the premises can have as one of its guiding principles ubiquitous deployment – thus making the network reasonably available to all residents regardless of demographic standing. Furthermore, appropriate business models can be implemented to help make some level of service available to nearly all residents.

1.2.3 Gigabit Service at Nationally Competitive Prices

Google Fiber has set the gigabit service bar at about $70 per month. In an abundant bandwidth model, this target is reasonably achievable.

1.2.4 LMG Functions as an Infrastructure and Policy Partner

The alternative that appears to best meet policy objectives, consumer demand, the four principles identified below (open and wholesale, carrier-class, high scalable bandwidth and open and independent architecture), and the needs of private sector service providers appears to be one in which LMG or a consortium including LMG owns the network and uses a third party asset manager to build, manage, and maintain the natural monopoly element in the telecommunications environment (that is the transport mechanism) as a public utility made available to private service providers who can then offer retail services. In other words, the best apparent 21st century telecommunications delivery solution is financially responsible ubiquitously deployed public open access fiber to the premises.

1.2.4.1 Financially Responsible

Communities considering a municipal telecommunications build should understand that one of the reasons private enterprise network owners have not deployed more advanced telecommunications services is because the cost is too high for them to be supported by the available profit margins. One of the advantages of a municipal project is the availability of long-term low interest financing for capital infrastructure projects.

However, the availability of favorable financing should not result in a careless fiscal environment. The municipal bonds used to back the debt must be paid. Some projects may be able to pay their operating expenses and debt service through direct project revenues. Others will need to measure tax increment benefits, cost savings, and other indirect revenues in order to show fiscal responsibility. In some cases, public policy objectives may justify network subsidies from general fund spending (i.e. taxes) or through special service funds (like utility fund transfers or special assessment areas).

Several tools exist to mitigate financial risk and support fiscal responsibility. Included among them are risk pooling, optimization of existing assets, utilization of third party expertise, and principal protection programs. Each of these tools is discussed in this report.

1.2.4.2 Ubiquitously Deployed

One of the ways cities differ from incumbent private network owners is in the desire to make services reasonably available to all residents and businesses – and to offer free or heavily discounted service to underserved and disadvantaged consumers. Incumbent private providers target implementation in areas that generate the highest returns on investment. Often certain franchise agreement stipulations impose ubiquitous builds on the incumbents but typically only at minimum service levels. Residential areas with target demographics and certain commercial areas will usually get better service than other retail, industrial, and residential areas.

While franchise agreement requirements and other regulatory efforts help bridge the digital divide in that they require ubiquitous service deployment, they typically have little effect diminishing disparity in types of available service. Furthermore, because incumbents tend to manage their network bandwidth as a scarce resource, many services are priced out of reasonable reach of lower income households and small businesses.

1.2.4.3 Public

Public networks can be sponsored by municipalities, counties, states, coalitions, inter-governmental agencies, or any imagined group that can be trusted with the maintenance of the public good. The role of public owner is not to compete directly with private enterprise solutions. Rather, democratic government institutions identify and provide “natural monopoly” services, common or public good services, and market failure services. 21st century telecommunications infrastructure shows characteristics of all three of these typical government response areas. A public network allows the government to provide the natural monopoly aspect of telecommunications (the infrastructure itself) while opening the non-monopoly competitive aspect of providing services to multiple providers.

1.2.4.4 Open Access

Public networks can best meet their policy objectives by adhering to principles of open access. That is, the network owner makes the physical communications medium available to multiple competing service providers.

1.2.4.5 Fiber to the Premises

Having resolved to provide a long-term competitive platform for multiple simultaneous service providers, public entities contemplating a telecommunications solution are left with few options other than active Ethernet fiber to the premises (FTTP).

We will address the technical arguments for this choice later. However, the anecdotal evidence for fiber is strong. You may frequently hear copper and wireless vendors saying something to the effect of, “It’s just as good as fiber.” You will never hear a fiber network owner justifying themselves by saying their network is just as good as wireless or DSL.

This is not to suggest there is no place for wireless. Wireless networks extend and augment a fiber network providing access where fiber is yet to be built and mobility that simply cannot be replicated on a wireline type of network like fiber to the premises.

1.2.4.6 It is a COMMUNITY Network

Having provided an introduction to financially responsible ubiquitously deployed public open access fiber to the premises it is appropriate to discuss that it is first and foremost a community endeavor before delving into more detail regarding the proposed business model. From the outset of each public open access project, the key stake holders must consider how their efforts will benefit the network owner, those financing the solution, the supported community anchor institutions, incumbent providers and network owners, and for the community’s residents and businesses.

1.2.4.6.1 Win for the Community

Communities who choose to upgrade their telecommunications infrastructure to 21st century open access fiber to the premises should expect to see economic development benefits as new businesses come into town to take advantage of the true choice of true broadband only open access fiber to the premises can offer. Further economic development benefits come as ubiquitously available broadband increases productivity, entrepreneurial opportunities evolve, and more workers take advantage of their new-found capability to work from.

Through ubiquitous deployment of very high speed broadband, cities can better manage traffic with enhanced sensors and cameras. Fire departments can have better access to information to save lives and stop the spread of fires. Intelligent alarm systems can even notify fire crews faster helping ensure quicker responses and minimizing damage. Police can monitor sensitive areas with cameras and, given proper integration, can control lighting, electronic locks, and other systems in their pursuit of community safety.

Utility providers in the community can better monitor and control the delivery of their services. Better monitoring and control helps utility providers meet consumer demand while simultaneously conserving resources.

Economic development. Public safety. Conservation. These and many other quality of life improvements are possible through effective deployment of public open access fiber to the premises.

1.2.4.6.2 Win for Financial Supporters

Deploying fiber to the premises is a capital intensive proposition. Some business analysts have argued that the wholesale-retail split model implemented in a truly open access network is not financially feasible because the network owner abandons service (or application) margins, loses control of the retail marketing environment, and abandons most price discrimination[39] opportunities.

While these concerns exist, a financially responsible project takes reasonable precautions to protect its financial supporters. While we will address these business analyst issues in more detail later, let's take a brief look at each of them here:

1. Service (Application) Margins
   Revenues from a traditional market funded vertically integrated monopoly provider must cover capital costs, operations, and profits. A publicly provided open access telecommunications utility typically has no profit motive. The public network owner need only generate revenues sufficient to cover capital costs and network operations. Service (or application) margins retained by the private service providers taking advantage of the network can generate profits for their owners, be reinvested to develop innovative applications, or both.
2. Retail Marketing Control
   A network owner in an open access model should avoid unnecessary interference with their private service providers marketing efforts but that does not mean they have to sacrifice all influence. In fact, clear brand use guidelines, robust awareness campaigns, and effective neighborhood fiber advocacy programs offer the network owner significant retail marketing power and responsibility.
3. Price Discrimination
   If the network owner elects a dark fiber leasing only model, they put themselves in a position of minimal price discrimination opportunity. If the network owner offers lit services and builds a suite of wholesale applications, they create a robust price discrimination environment.

Anupam Banerjee and Marvin Sirbu of Carnegie Mellon University researched the financial implications of the open access model and published their results in the paper "FTTP Industry Structure: Implications of a wholesale retail split."[40] They conclude, "In spite of interfering with a wholesaler's ability to price discriminate, a wholesale-retail split is economically feasible. A wholesaler can recover its cost and as long as a significant number of homes do not have a zero willingness to pay for broadband data service, a wholesaler is almost as profitable as a vertically integrated entity." Further, "Even in the presence of a (cable) incumbent that offers voice, video and data services, a wholesaler is as likely to recover its costs as a vertically integrated entity."

In sum, a financially responsible project can effectively provide for its financial backers' return on investment.

[39] That is, the ability to offer a variety of products, some of which generate more revenue or offer higher margins.
[40] Banerjee, Anupam and Marvin Sirbu (June 2008). "FTTP Industry Structure: Implications of a wholesale retail split." Carnegie Mellon University. Retrieved 12 September 2011 from http://web.si.umich.edu/tprc/papers/2006/648/Banerjee_Sirbu%20TPRC_2006.pdf.

1.2.4.6.3 Win for Community Anchor Institutions

We touched on potential benefits of a fiber to the premises network for fire and police departments. We cannot neglect the striking benefits available to other community anchor institutions.

True broadband can:

- Improve government efficiencies and make public services and the tools of democracy more readily available to the citizens of participating communities,
- Extend classrooms into homes and across communities making education more accessible and more integrated with students' lives,
- Offer healthcare monitoring to vulnerable populations increasing their care while simultaneously reducing the resources (and costs) associated with providing that care,
- Expand libraries well beyond the walls enclosing their collections brining the world to the community and the community to the world, and
- Otherwise support public services.

1.2.4.6.4 Win for Incumbent Providers and Network Owners

Many communities considering deploying telecommunications infrastructure as a public utility face opposition from incumbent service providers – especially facilities based providers who often have extensive networks of their own. Some states, largely under the influence of incumbent provider lobbyists, have even established prohibitions preventing municipalities from deploying public utility telecommunications networks[41].

However, a compelling argument can be made that a community fiber network is an extremely valuable asset for incumbent providers. Wall Street puts some significant pressure on incumbent providers to control their infrastructure costs (see Saul Hansell, "A Bear Speaks: Why Verizon's Pricey FiOS Bet Won't Pay Off"[42] for example). Based on an effective community fiber to the premises network, incumbents can migrate out of the capital intensive business of building, maintaining, and upgrading their physical infrastructure and focus on providing extraordinary services to retail customers.

1.2.4.6.5 Win for Residents and Businesses

The public open access fiber to the premises model extends true choice of true broadband to all residents and businesses.

First, without powerful penalties in franchise agreements or other regulatory requirements, most private companies are inclined to build and support only areas where they can extract the greatest profits. This would leave poorer areas or areas that are more costly to build to unserved or underserved

[41] The Baller Herbst Law Group does a very good job of summarizing state preemption laws at http://baller.com/comm_broadband.html#barriers. The Baller Herbst data is visually summarized by Community Broadband Networks (http://www.muninetworks.org/) on their Community Broadband Network Map at http://www.muninetworks.org/communitymap.

[42] Hansell, Saul (19 August 2008). "A Bear Speaks: Why Verizon's Pricey FiOS Bet Won't Pay Off." The New York Times: Bits. Viewed 4 August 2012 at http://bits.blogs.nytimes.com/2008/08/19/a-bear-speaks-why-verizons-pricey-fios-bet-wont-pay-off/.

by the incumbent providers. A ubiquitously deployed public infrastructure solution overcomes this challenge and extends true broadband to all businesses and residents in the community.

Next, broadband has many "definitions". The National Broadband Map defines broadband as "a high-speed, always-on connection to the Internet" and states "[f]or information to be included on the National Broadband Map, the technology must provide a two-way data transmission (to and from the Internet) with advertised speeds of at least 768 kilobits per second (Kbps) downstream and at least 200 Kbps upstream to end users."[43] Always on and sub 1Mbps download speeds – that's a pretty low bar. True broadband should be sufficient bandwidth for anything you may do today and should have a reasonable upload path for the things you may want to do tomorrow. Broadcast and digital cable TV quality high definition video requires about 16 Mbps. Blue-ray quality video consumes about 35 Mbps. Small screen high definition video conferencing requires at least 1.5 Mbps upload speeds. Surely our 21st century definition of broadband should support the needs of today and offer speed tiers starting at 30 Mbps and going to 1 Gbps and above. Public open access fiber to the premises can offer true broadband.

Finally, in most communities, broadband is available from one or two wireline providers and two or three wireless providers. Calling this choice recalls the cliché attributed to Henry Ford, "You can have any color Model T so long as it is black." Walk into a grocery store and see if there are more than three to five bakeries represented in the bread aisle. True choice – generating real competition – demands a broad range of service providers. Unfortunately, spectrum limitations and infrastructure costs limit the number of broadband providers that can serve a given market. That is unless the community has deployed an open access network that can support multiple providers simultaneously.

1.3 Guiding Principles

In the RFI, LMG expresses a commitment to making the critical investments and policy modifications required to ensure that it is prepared to meet the demands of a 21st century economy. This requires that LMG provide the resources necessary for businesses, residents, and government to succeed and thrive in order to build on the economic base already established and to be a global leader and pioneer. LMG recognizes that availability of and access to a high-speed broadband network has quickly become viewed as critical urban infrastructure similar to electricity, water, roadways, and airports and that the current state of broadband in the city (and the nation as a whole) is an inadequate foundation to propel the city forward in a technology-based economy.

Like a Rubik's cube, the multitude of concerns inherent in public broadband projects are interrelated in a complex fashion: business modeling, financing, cash flow forecasting, legal issues, public relations, technology, maintenance, operations and other "sides" of the cube all have solutions – both short-term and long-term – that are interdependent. To simultaneously solve each of these areas requires that they be addressed under a common set of goals or "Guiding Principles". Trying to solve one issue without consideration for the others – in absentia of guiding principles – may leave planners with a superficially pleasing one-sided solution while the rest of the puzzle remains jumbled.

[43] See http://www.broadbandmap.gov/classroom.

Careful consideration yields four key guiding principles as the philosophical drivers for public broadband projects:

- A public project must be open access and offer wholesale services,
- A public project must offer carrier class security, functionality, and reliability,
- A public project must offer high scalable bandwidth, and
- A public project must be based on an open and independent architecture.[44]

1.3.1 Open and Wholesale

One of the objectives expressed in the RFI is to increase competition – recognizing that competition will help improve access to cost-effective, reliable, and plentiful bandwidth and will drive implementation of innovative broadband applications that can spur economic development and improve quality of life. It goes without saying that monopolization is anathema to competition. As we described the current state of broadband, we have argued that monopoly has played a large role in stalling the US broadband environment to where it is today. As monopoly/duopoly control of the telecommunications environment is responsible for many of our broadband problems, it simply makes no sense for municipalities to trade one monopoly for another and deploy a monopoly telecommunications infrastructure (ala Chattanooga, Tennessee or Lafayette, Louisiana). Philosophically, cities should be averse to deploying a monopoly system and should shun the idea of delivering services themselves. Rather, they should perceive for themselves the more traditional municipal role contemplated by LMG – an infrastructure and policy partner. The actual delivery of services should be left to competing private sector service providers – as many qualified service providers as the market can bear. This open and wholesale or open access model ensures that the natural monopoly element of delivering broadband services – the infrastructure – is available to a wide variety of competing private sector firms for the delivery of goods and services.

1.3.2 "Carrier-Class"

"Carrier-class" is a fairly vague term. The PC Magazine online encyclopedia defines it as "…hardware and software used in large, high-speed networks. It implies extremely reliable, well tested and proven. Telephone companies, major ISPs and large enterprises purchase carrier-class equipment."[45] In their 2007 article "Carrier-Grade: Five Nines, the Myth and the Reality", Wedge Greene and Barbara Lancaster conclude, "Carrier-grade is actually an intangible expectation and explicit promise that the equipment vendors will provide the best equipment possible and a clear, immediate communication of issues related to equipment. And that service providers will also provide the best network possible to their customers and keep a clear and immediate communication channel open concerning service impacting

[44] These principles were outlined by Jeff Fishburn in his article in Chinlon Lin's book. Fishburn, Jeff (2006). "Broadband Fiber-to-the-Home Technologies, Strategies, and Deployment Plan in Open Service Provider Networks: Project UTOPIA". In Chinlon Lin Broadband Optical Access Networks and Fiber-to-the-Home: Systems Technologies and Deployment Strategies. John Wiley & Sons; Chichester, UK.
[45] http://www.pcmag.com/encyclopedia_term/0,1237,t=carrier+class&i=39298,00.asp

An analogy may help illustrates the concept of an open and wholesale network: When cities realize the need to build a municipal airport they don't call up the commercial airlines and try to convince them to do it. Rather, they form an airport authority with the sole purpose of building and operating the municipal airport. The Authority builds runways, terminals, and other structures, but it does not fly the planes. Instead, private sector airlines use the open and wholesale infrastructure and compete for retail ticket sales. Because the high cost of the airport is spread over multiple airlines using the facility, the cost to use the airport becomes much lower than if each airline had to build its own facility.

When an airline sells tickets to passengers, the cost of the ticket covers the runway, gate, and other fees the Airport Authority assesses airlines for use of the airport. These fees cover airport operating expenses, pay off the bonds used to finance its construction, and provide funds for future improvements. The Airport Authority does not interact directly with passengers - it does not charge the passengers fees, nor does it consider them customers. Instead, the airlines are the Authority's customers. The arrangement allows the airlines to compete against each other, not against the Airport Authority. This competition in a shared facility helps airlines focus on value, services, and other passenger oriented functions rather than on maintenance of the airport. This benefits customers because airlines become innovative in their approaches to win and keep customers.

Similarly, by adhering to the principle of open and wholesale, municipalities build and maintain the broadband infrastructure, but they do not engage in selling services to the end-user. Rather, they open the infrastructure to private sector service providers. Ideally, multiple service providers compete with each other for market share. The service providers are the customers of the municipal network owner. The private sector still owns the relationship with the end-user subscribers and, being freed from concerns about maintaining infrastructure, they are able to focus on their service offerings. This stimulates innovation as providers seek to differentiate themselves from one another and it helps ensure that prices remain at competition driven market levels. Additionally, since government financing for the network can secure lower interest rates and longer terms than private industry can, the cost of debt service is lower than what it would be for private industry. These cost savings benefit the service providers who end up paying lower access fees. Because their overhead is lower, service providers can price their services at lower retail rates or use free revenue for research and development, thus benefiting the end user.

situations. And lastly that the supply chain communication is two way, with feedback from the buyer going to the provider so they gauge and support continuous improvement."[46] Brocade Networks' 2009 article "What is Carrier Grade Ethernet" helps refine the overall understanding of what a carrier grade network is (Brocade Networks' focus is on Ethernet which proves to be relevant as 21st century networks

[46] Greene, Wedge and Barbara Lancaster (18 March 2007). "Carrier-Grade: Five Nines, the Myth and the Reality." LTC International – published in Pipeline Magazine in April 2007.

tend to be packet based Ethernet or Ethernet-like networks) by defining five attributes carrier-grade Ethernet must possess: 1) standardized services, 2) scalability, 3) reliability, 4) quality of service, and 5) service management. In a 2001 white paper titled “Carrier-Class Ethernet: A Services Definition”, Appian Communications defines carrier-class Ethernet around the services the network can deliver – especially: a) granular, SLA-managed bandwidth guarantees, b) rapid, even on demand service activation, c) SONET/SDH resilience and manageability, d) services that span the metro and wide area, e) high-speed migration for current data services, f) a simple strategy to sell new and more services, g) integration with existing TDM services, and h) greatly reduced operating and capital costs. The fundamental driver underlying each of Appian Communications’ services is the ability of service providers to increase revenues by reliably offering new packet driven services while simultaneously controlling costs.

Fundamentally, carrier-class suggests those attributes required to enable a service provider to offer customers reliable professional services. These are the attributes Wedge and Lancaster call “intangible” and that Brocade Networks and Appian Communications try to make tangible through enumeration. These attributes have to do with reliability, capacity, security, flexibility, and other features expected by service providers from the network that will function as their service foundation. Service providers require the network to perform with carrier-class attributes – tangible and intangible. From the smallest start-up to global giants with international reputations, each is willing to entrust those reputations to the network only if they are confident the network meets carrier-class expectations. From the physical design to the overarching operational model, the infrastructure must deliver exceptional performance and offer absolute security.

While “carrier-class” may not be easily defined or readily measured it is self-evident guiding principle for municipal open access network projects. This requirement, though seemingly self-evident, is sustained as a guiding principle through market research. Scientifically administered surveys have been used to determine the characteristics required for municipal networks to see market success. In nearly every case, the number one or number two concern for businesses and residents alike is reliability.

1.3.3 High Scalable Bandwidth

In addressing the first principle – being open and wholesale – municipal networks must meet the needs of multiple service providers simultaneously. In other words, they have to be capable of delivering all the current services available as well as higher-bandwidth consuming future services from all service providers on the network. Thus, the system has to start out with tremendous bandwidth capacity and be able to grow larger still. And in growing, it has to also evolve. In a way, this is a requirement to make the system "future proof," meaning that it is capable of adapting to new and emerging technologies that otherwise might obsolete the investment.

The value of incorporating this principle is obvious. Just as "whistle stop" communities had an advantage over those bypassed by the railroad in the old west, cities with the ability to support multiple current and future services will have economic as well as quality-of-life advantages over other communities. And it ensures that the investment made today won't become outdated because the system is designed to scale to meet future demands.

Many incumbents argue the bandwidth they provide is more than adequate and, that as soon as the market demands it be done, they will upgrade their services. This argument harks back to Henry Ford saying of the Model-T in 1909, "Any customer can have a car painted any color that he wants so long as it is black." More germane to the current discussion is the flood of telephone styles that came to market after AT&T abandoned their telephone device monopoly. In the case of bandwidth, like with colors of automobiles and styles of phones, more availability may create more demand. "Figure 11: Internet Traffic per User by Country"[47] indicates that South Korea, with its substantially higher bandwidth availability than the US, has significantly more demand for that bandwidth.

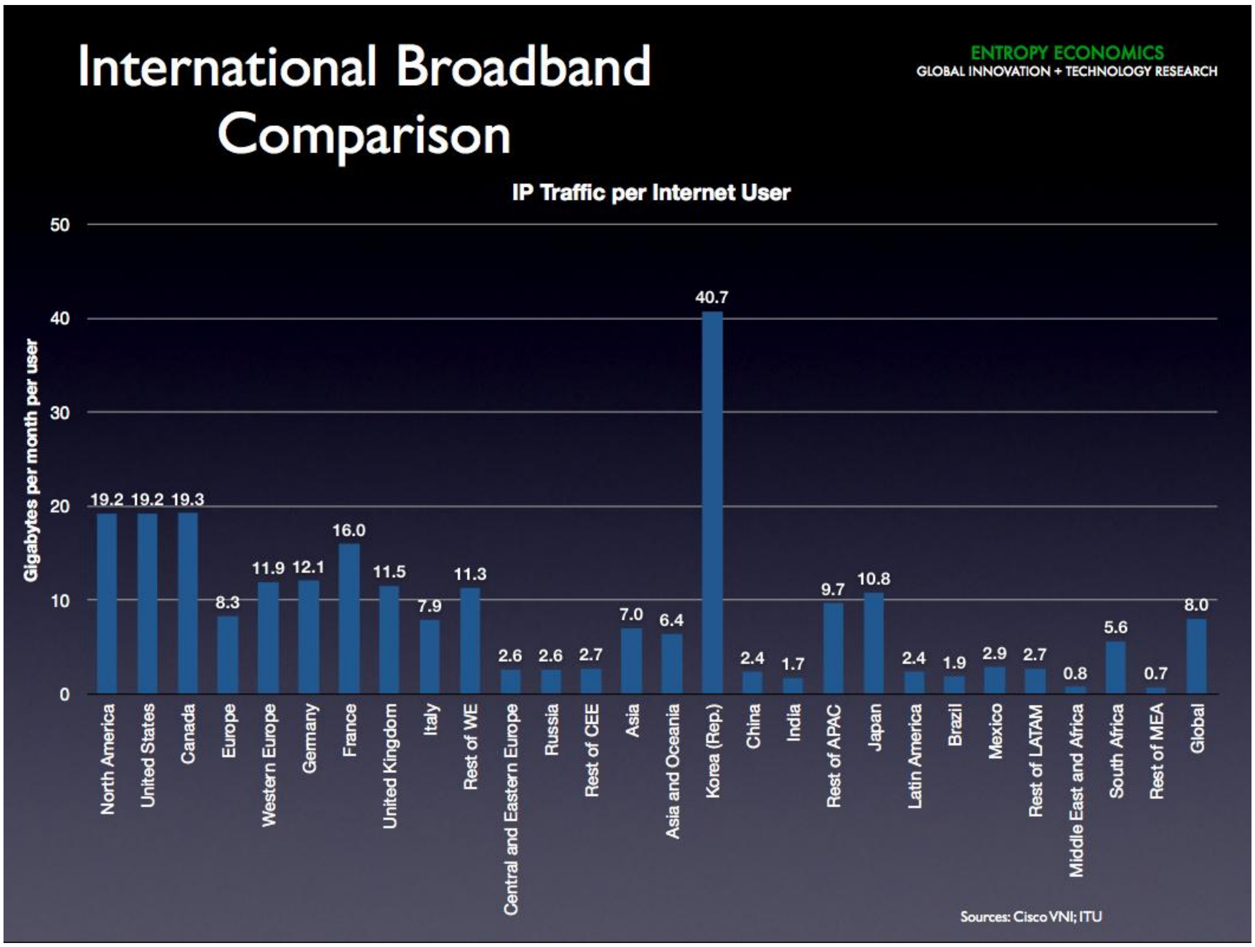

Figure 11: Internet Traffic per User by Country

Interestingly, Waverman's 2008 "The Connectivity Scorecard"[48] ranks the United States first and Korea 10th of 16 innovation driven and emerging economies. Waverman explains:

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[47] The graphic is from Swanson, Bret (14 October 2010). "International Broadband Comparison, Continued." Maximum Entropy. It is based on data at Cisco Visual Networking Index (VNI); http://www.cisco.com/en/US/netsol/ns827/networking_solutions_sub_solution.html.

[48] Waverman, Leonard, Kalyan Dasgupta, and Justin Tonkin (18 January 2008). "The Connectivity Scorecard." LECG Nokia Siemens Networks.

Korea scores well in the government and consumer components of the Scorecard, which tend to dominate other indices, but quite poorly in business usage and complementary assets and services…. Korea does not appear to be a top performer in the business arena – indeed, Korean productivity on a per worker basis is much lower than European or North American productivity…. Other sources (not used in computing index scores) confirm that in business telephony usage and spending, Korea lags well behind other Asia-Pacific Innovation driven nations like Japan and Australia in the use of business enterprise telephony solutions. (p. 21)

The disconnect between South Korea's high Internet bandwidth and IP usage per user and their Waverman Connectivity Scorecard results begs two questions:

1. What about South Korea's broadband policy is failing to extend broadband's economic development benefits to complementary sectors in Korea's economy?
   Waverman suggests Korea's failure is largely due to the major industries within their existing economy. The US, as demonstrated by its connectivity score is positioned much better to capitalize on higher bandwidth availability.
2. If the South Korea-like bandwidth were available to US businesses, how much more usage (or demand) would that create and what would that usage add to US economic development?

This is a question we can only know the answer to if capacity is increased; if high scalable bandwidth is a central principle throughout the network (first mile, middle mile, and last mile segments). We have already identified that many incumbents believe they deliver adequate bandwidth – therefore, relying on them to expand bandwidth to drive new demand is a tenuous proposition. It is up to the public sector to lead the way towards expanded bandwidth and greater economic development.

1.3.4 Open and Independent Architecture

While many proprietary solutions could be employed to deliver the results called for in the first three principles, this fourth principle aims at ensuring that the efficiencies of the system are always maximized. By requiring solutions to be standards-based and founded on open technologies, municipal open access network owners can "shop around" for the best deals and are not beholden to any one particular company or proprietary invention. While there is often a benefit to a proprietary solution that can outweigh the negatives of diminished choices, the ultimate benefits usually derive from vendors who are actively competing for business and responding to competition with efficient pricing and more innovative solutions.

2 Scope of Requested Information

The RFI describes the scope of requested information as:

A. Geographic Areas
B. Desired Network Characteristics
C. Public Assets and Infrastructure

2.1 Geographic Areas

In the RFI, LMG writes, "LMG invites responses that include ideas and recommendations regarding the development of a gigabit fiber network in defined geographic areas where demand for the service is likely to be sufficient…" The RFI goes on to suggest the needs of the City, particularly service to underserved and disadvantaged residential areas, can be otherwise met through wireless and future network expansion.

We disagree.

We believe a ubiquitous network deployment makes sense both from a public policy perspective and from a business perspective.

2.1.1 Public Policy Reasoning for Ubiquitous Deployment

One of the ways cities differ from incumbent private network owners is in the desire to make services reasonably available to all residents and businesses. Incumbent private providers target implementation in areas that generate the highest returns on investment. Often certain franchise agreement stipulations impose ubiquitous builds on the incumbents but typically only at minimum service levels. Residential areas with target demographics and certain commercial areas will usually get better service than other retail, industrial, and residential areas.

While franchise agreement requirements and other regulatory efforts help bridge the digital divide in that they require ubiquitous service deployment, they typically have little effect diminishing disparity in types of available service. Furthermore, because incumbents tend to manage their network bandwidth as a scarce resource, many services are priced out of reasonable reach of lower income households and small businesses.

2.1.2 Business Reasoning for Ubiquitous Deployment

Typical feasibility surveys place likely market penetration for fiber to the premises overbuild projects between 55% and 70% with the potential market arcing close to 80%. "Table 1: Composite Market Survey Results" combines results from several market surveys in a variety of markets. The data is based on interviewees receiving some background describing fiber to the premises, how an open access network functions, and what the costs and benefits to subscribers would be. They are then asked some form of the question, "How likely would you be to switch to the fiber to the premises network?" Response options are given in some form of: Very Likely, Somewhat Likely, Neutral, Somewhat Unlikely, and Very Unlikely.

Residential				Business/Commercial
100% of Very Likely & Somewhat Likely	76%	Potential Market	79%	100% of Very Likely & Somewhat Likely
100% of Very Likely plus 50 to 70% of Somewhat Likely	59% to 66%	Likely Market	61% to 68%	100% of Very Likely plus 50 to 70% of Somewhat Likely
100% of Very Likely	42%	Minimum Market	43%	100% of Very Likely

Table 1: Composite Market Survey Results

Yet, while expecting residential take rates of up to 75%, many overbuild projects struggle at below 20% take rates. We believe diffusion theory, network effects, and tipping points both explain why overbuild networks fail to meet their probable take rate estimates and reveal the secret to higher take rates.

2.1.2.1 Diffusion Theory

In spite of survey results, diffusion theory predicts typical overbuild marketing techniques will result in take rates at about 17%. In 2002 Strategic Research Institute (SRI) produced a market survey titled "Closing the Chasm… Introducing New Products/Services into the Marketplace by Integrating Diffusion of Innovations with Product Life Cycle" by G. Gary Manross and Everett M. Rogers[49]. To quote from this report:

[49] Manross, G. Gary and Everett M. Rogers (2002). "Closing the Chasm… Introducing New Products/Services into the Marketplace by Integrating Diffusion of Innovations with Product Life Cycle." Strategic Research Institute.

Diffusion theory says that the diffusion of an innovation is the process by which that innovation "…is communicated through certain channels over time among members of a social system."[50] *The main focus of diffusion theory is on communication channels, both mass media and interpersonal, which transmit information about an innovation.*

Rogers' diffusion model suggests that there are five categories of people involved in the adoption process ([Figure 12: Diffusion Model]):

- *Innovators (2.5% of the target population)*
- *Early Adopters (13.5%)*
- *Early majority (34%)*
- *Late majority (34%), and…*
- *Laggards (16%)*

These five categories of individuals have distinct characteristics that define their roles in the diffusion process.

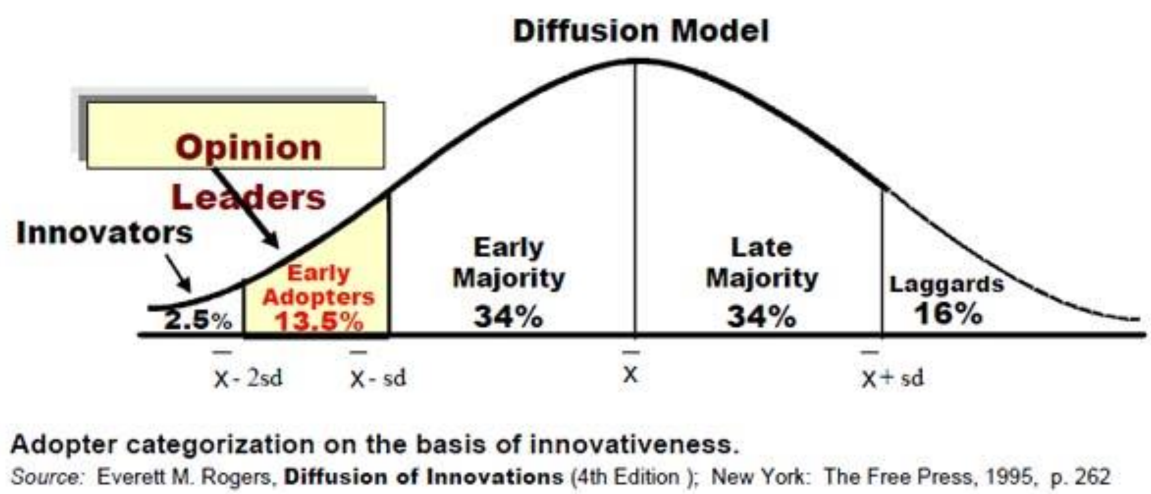


Figure 12: Diffusion Model

When an innovation (e.g., new product or service) is introduced in a marketplace, those in the category of innovators are the first to "try" the new product; and, in many cases, subsequently adopt it. This takes place in a relatively short period of time. Innovators, by nature, are likely to be risk takers who are willing to try new ideas because they want to be the first ones to do so. As a result, those in the other four categories seldom pay much attention to these individuals.

[50] Rogers, Everett M. (1983). *Diffusion of Innovations* (3rd edition). New York, NY: The Free Press.

But if a given innovation being introduced in the marketplace is, indeed, a viable product or idea, then it is likely to begin gaining wider acceptance fairly rapidly. This process, of course, is influenced by advertising and price[51]*. According to Kalish, "…The rate of adoption is determined by awareness (of the innovation), which is (heavily impacted) by advertising, and the rate of growth of (the) potential adopter population, which is controlled (to a large degree) by price."*

Those in the second category – Early Adopters – are seen by both the early majority and late majority (categories three and four, respectively) as being opinion leaders. As a result, they are often thought of as the most important category of adopters, especially from a marketing perspective. Early Adopters are information seekers. While willing to take some amount of risk (certainly more than those in the three subsequent categories), these people want to make INFORMED DECISIONS. In terms of attributes, Early Adopters are often upwardly mobile and among the higher SES (socio-economic status), compared to other adopter categories.

The third category – early majority – pay attention to Early Adopters. Those in the late majority are inclined to follow those in the early majority. Laggards may never adopt a given innovation; at least not during the initial product life cycle.

…

Marketing researchers who have studied diffusion…paid particular attention to the Innovators and the Early Adopters, since they help define consumer behavior patterns.

Opinion leaders…are those from whom others seek leadership and advice. Since these individuals influence the opinions of others, it is believed that attention must be given to them while developing a marketing plan. The assumption is that IF opinion leaders can be convinced to try a product, and subsequently develop a favorable attitude toward that product, they will communicate this attitude to others in the social system (the target market), thus, encouraging broader adoption.

If Early Adopters are to influence the opinions of others, then these individuals MUST be effectively communicated with relatively early in the product life cycle. Additionally, it is important to identify the media habits of opinion leaders, so that we know the optimum methods of communicating with them.

Typical municipal overbuild marketing efforts focus primarily on door-to-door campaigns. Door-to-door marketing is very good for capturing innovators and early adopters. However, the early majority is inclined to wait for a recommendation from a trusted opinion leader before adopting a new product. No matter how good they are at their jobs, door-to-door sales staff are seldom considered trusted

[51] Kalish, Shlomo (1985). "A New Product Adoption Model with Price, Advertising and Uncertainty," Management Science, Vol. 32, No. 12, December, pp. 1569-1585.

opinion leaders. Thus, door-to-door efforts should expect to see adoption by innovators and early adopters – or, about a 16% take rate.

The Manross and Rogers report goes on to define the existence of a gap or "chasm" between early adopters and the early majority. Continuing with the report:

> *The adoption process begins with the notion that when prospective adopters (e.g., buyers) become aware of a new product, service and/or idea that is appealing to them, the KNEE JERK reaction is, in fact, a desire to adopt (purchase), or at the very least, give the innovation a try. In the short term, the knee jerk reaction leads to a decision to purchase.*
>
> *What is different between those individuals in the Early Market (visionaries) and those n the Mainstream Market (pragmatists) is that the former (visionaries) are far more likely to act on their knee jerk desire to adopt (purchase the product); while the latter (pragmatists) are inherently not risk takers. As a result, before adopting (making a decision to purchase), those in the Mainstream Market feel compelled to first "check it out" with someone they trust (an opinion leader); then make the decision to purchase or not to purchase. The higher the level of risk (e.g., the higher the price), the more likely pragmatists are to seek advice from someone they trust before making a decision to purchase.*
>
> *Thus, what is likely to happen if:*
>
> 1. *The visionary to whom the pragmatist turns to for advice isn't aware of the product/service for which the inquiry is being mad?, or worse…*
> 2. *The visionary is, indeed, aware of the product/service, but does NOT perceive it as having sufficient value to purchase?, or equally problematic…*
> 3. *The visionary likes the product/service for which the inquiry is being made, but the visionary's reasons for adopting the innovation have nothing to do with the pragmatist's reasons for being interested in the innovation?...*
>
> *Clearly, the likelihood is high that each of the above scenarios will result in a decision on the part of the pragmatist NOT TO BUY…*

We would add a fourth problem scenario – the visionary likes the product/service for reasons the pragmatist is interested in but the product is not available to the pragmatist.

Many efforts must be undertaken to maximize the ideas presented in the diffusion theory model. One of them is to ensure the products being talked about in grocery store aisles, at neighborhood BBQs, and while watching little league games are available to the pragmatists asking the questions and the visionaries making recommendations.

2.1.2.2 Network Effects

A product displays positive network effects when more usage of the product by any user increases the product's value for other users. While real study of network effects did not begin until the early 1970s, Theodore Vail provided this explanation in AT&T's 1908 annual report[52]… After describing the economies of scale, innovation, and legal benefits of the Bell System's integrated vertical cooperation with its affiliated companies Vail spends some time showing:

> *There is now a decided tendency on the part of the public to favor consolidation wherever there are two exchanges. A great difficulty in the way is that, as a rule, much of the duplication of plant cannot be utilized for many years, if ever.*
>
> *Gradually the public is becoming convinced that – quoting from last year's report –*
>
> *'Two exchange systems in the same community, each serving the same members, cannot be conceived of as a permanency, nor can the service in either be furnished at any material reduction because of the competition, if return on investment and proper maintenance are taken into account. Duplication of plant is a waste to the investor. Duplication of charges is a waste to the user.' (pp. 20-21)*

He then writes:

> *A telephone – without a connection at the other end of the line – is not even a toy or a scientific instrument. It is one of the most useless things in the world. Its value depends on the connection with the other telephone – and increases with the number of connections.*
>
> *The Bell system under an intelligent control and broad policy has developed until it has assimilated itself into and in fact become the nervous system of the business and social organization of the country.*
>
> …
>
> *Cheapness is relative to value, not to price. Value in telephone service depends on development, extent of system, certainty and promptness. (pp. 21-23)*

To paraphrase Vail, a gigabit network connection without a gigabit on the other end of the line (and throughout the line) is one of the most useless things in the world. That is, if the only places a network user wants to go focus their attention on only require 5 Mbps download speeds, the user doesn't need more than 5 Mbps.

It is no exaggeration to say that the Internet has changed the way many Americans work, communicate, and live their lives. E-mail alone would bear that same distinction, and "Google" has become a verb

[52] American Telephone and Telegraph Company (16 March 1909). "1908 Annual Report of the Directors of American Telephone and Telegraph Company to the Stockholders." Viewed 24 November 2012 at http://www.beatriceco.com/bti/porticus/bell/pdf/1908ATTar_Complete.pdf.

because of its ubiquitous place in the lives of many Internet users. Well-known examples of other game-changing Internet offerings run the gamut of experience:

- Amazon.com and other successful online retailers changed the way Americans buy everything from books to groceries. Consumers often get better deals than in the past, too; easy comparison shopping means online and bricks-and-mortar stores face real price competition every day.
- eBay and other auction sites didn't just give people an alternative to setting up a yard sale in July – they gave entrepreneurs a platform for creating viable businesses out of their homes.
- Monster.com and similar sites gave job seekers instant access to employment listings, worldwide and at every level. Looking for work no longer means waiting for the Sunday newspaper to hit the doorstep.
- Craigslist has further eroded the importance of that local newspaper by offering free "classified ads" for any item or service you wish to sell – or give away.
- YouTube has given everyone with a video enabled cell phone the ability to post and play videos, instantly, from anywhere.
- Netflix and Hulu have had a dramatic impact on the way people watch movies and television.
- Skype made traditional landline phone superfluous for anyone with a computer and high-speed Internet access.

In fact, look at any consumer or business relationship – banking, trading stocks, watching video of the latest news, interacting with your local government – and the Internet has changed it. During a time when most users had dial-up or relatively slow cable or DSL broadband connections, the Internet enabled the creation of applications and services that, as recently as 10 years ago, were impossible for most people to imagine.

And that was with application developers limiting their imagination to the bandwidth the incumbent transport networks could offer.

Now imagine the innovation and possibilities presented by truly competitive and truly high-speed fiber connectivity. Fiber to the premises networks hold the promise of expanding on those previous innovations and acting as a springboard for innovations that most people can't yet imagine. In education and healthcare – in commerce and entertainment – the potential advances enabled by fiber's huge bandwidth are of the type that could lift the entire population. A fiber network offers enough bandwidth, for example, to support an interactive, high-definition video link between a teacher and a sick child in a hospital – enabling the child to stay connected to the classroom.

Is it possible to envision what educational opportunities, businesses, or social connections might be on the horizon? Perhaps some of them – but certainly not all. With open access fiber to the premises, the network owner does not have to. The network owner needs to build an environment large enough so that the value of developing applications that take advantage of the capacity of fiber becomes enticing to the entrepreneurs, software developers, and others with the ideas and imagination. As applications are deployed, their value is typically enhanced by more potential and actual users. New applications will bring new subscribers and new subscribers will inspire new applications.

The network also has to be able to reach the consumers' desired end points. Again, business practices call for ubiquitous deployment.

2.1.2.3 Tipping Points

Malcolm Caldwell's 2000 book The Tipping Point: How Little Things Can Make a Big Difference[53] describes three factors critical to tipping an "epidemic":

1) The "Law of the Few" or as Gladwell states, "The success of any kind of social epidemic is heavily dependent on the involvement of people with a particular and rare set of social gifts." Gladwell defines the required social gifts as:
   a) "Connectors" or people who "link us up with the world… people with a special gift for binding the world together." These people span multiple social and professional worlds and are able to connect people from these various worlds with each other.
   b) "Mavens" or people who collect information – especially about the marketplace – almost as if it were a hobby. "Mavens" are critical to the diffusion theory as they are the trusted sources or opinion leaders to whom the early majority turns. The unbiased recommendation of a maven is the greatest influencer to overcome (or reinforce) the early majority's resistance to their knee jerk reaction to buy a new service.
   c) "Salesmen" who persuade people with their charisma and negotiation skills.
2) The "Stickiness Factor" or the specific content of a message that renders its impact memorable and actionable.
3) The "Power of Context" which suggests human behavior is driven by current environment as much or more than personality traits or other characteristics.

Perhaps as pertinent to open access fiber to the premises as anything in Gladwell's work is the analogy he provides of a tipping point in the endnotes to the introduction:

> *The best way to understand the Tipping Point is to imagine a hypothetical outbreak of the flu. Suppose, for example, that one summer 1,000 tourists come to Manhattan from Canada carrying an untreatable strain of twenty-four-hour virus. This strain of flu has a 2 percent infection rate, which is to say that one of every 50 people who come into close contact with someone carrying it catches the bug himself. Let's say that 50 is also exactly the number of people the average Manhattanite – in the course of riding the subways and mingling with colleagues at work – comes into contact with every day. What we have, then, is a disease in equilibrium. Those 1,000 Canadian tourists pass on the virus to 1,000 new people on the day they arrive. And the next day those 1,000 newly infected people pass on the virus to another 1,000 people, just as the original 1,000 tourists who started the epidemic are returning to health. With those getting sick*

[53] Gladwell, Malcolm (29 February 2000). The Tipping Point: How Little Things can make a Big Difference. Little, Brown and Company.

> *and those getting well so perfectly in balance, the flu chugs along at a steady but unspectacular clip through the rest of the summer and the fall.*
>
> *Bu then comes the Christmas season. The subways and buses get more crowded with tourists and shoppers, and instead of running into an even 50 people a day, the average Manhattanite now has close contact with, say, 55 people a day. All of a sudden, the equilibrium is disrupted. The 1,000 flu carriers now run into 55,000 people a day, and at a 2 percent infection rate, that translates into 1,100 cases the following day. Those 1,100, in turn, are now passing on their virus to 55,000 people as well, so that by day three there are 1,210 Manhattanites with the flue and by day four 1,331 and by the end of the week there are nearly 2,000, and so on up, in an exponential spiral, until Manhattan has a full-blown flu epidemic on its hands by Christmas Day.*

While not specifically describing them the analogy suggests three concepts critical to the successful adoption of open access fiber to the premises in a community or region and across the nation. Gladwell does not clearly define them in his book so we will call them the relevant variables, the fulcrum, and the population.

Relevant variables are those factors that, given an adjustment, make a real difference in the system. If, for example, we want to freeze a cup of water, the amount of contaminates in the water and, especially, the temperature are relevant variables. The cup's color or the style of its handle have no impact. In Gladwell's Canadian Flu analogy, the number of people encountered by each sick person and the infection rate of the flu are relevant variables. The infected person's job or the shoes they are wearing are not.

The impact of the relevant variables depends on the fulcrum – or the constellation of relevant variables that exists around the tipping point to maintain equilibrium. Very minor changes to relevant variables around the fulcrum make significant changes. Our cup of water will never freeze if the temperature is kept at a constant 33 degrees. However, a very small 2 degree change in temperature will turn the water to ice. At 35 degrees or at 29 degrees a 2 degree change will have no effect. At 60 degrees, even a 20 degree temperature change will fail to achieve the desired effect – ice. While physics does not allow it to happen while freezing water, it may sometimes be easier to change the fulcrum point than to adjust the relevant variables. That is, if you have 60 degree water and you are trying to have ice, you may need to move the freezing point of water instead of cooling the water.

Finally, the total possible population has a significant impact on the spread of a desired effect. In Gladwell's Canadian Flu analogy, the exponential epidemic spiral will end when everyone who can get sick is sick and a new saturation point – a new fulcrum – is reached. With our water, we will never get a quart of frozen water if we are starting with a cup.

When proliferating open access fiber to the premises in a community or region it is important to identify the relevant factors and to implement and measure actions designed to affect them or to adjust the fulcrum point. Further, it is critical – from the feasibility stage and throughout the life of the project to know the constraints of the population.

Finally, it is critical to address the “stickiness factor”. A fiber network must offer services not available on traditional copper networks and must offer them to as many customer desired end points as possible.

2.1.2.4 The Solution: Ubiquitous Deployment

To make the most of diffusion theory, network effects, and tipping points, a new network entrant needs to build as many addresses as possible in as short of time-frame as possible. A ubiquitous deployment helps accomplish this goal.

2.2 Desired Network Characteristics

LMG describes desired network characteristics that can only be achieved through gigabit open access fiber to the premises.

2.2.1 General Requirements for all Technology Solutions

LMG describes a network in which:

> *…customers should be able to attach any devices to the network, as long as they do not impair network performance. Customers must also be able to post and access any lawful content on non-discriminatory terms. Data must be encrypted while traversing the broadband network in order to ensure the security and privacy of customers.*
>
> *The network must be characterized by a transport infrastructure that is physically and logically redundant and provide raw Layer 2 transport in addition to IPv4 and IPv6 Layer 3 routing. The infrastructure must be capable of providing 99.9% availability, be resilient with low latency and jitter, and ensure that packets sent and received at the network edges are identical. Finally, the network must permit the adoption of technologies such as DWDM, LTE, 802.11ac and other technologies as they become standardized or gain a significant market share.*

We have worked with a variety of network architectures through the years and determined that the network architecture OHIvey deploys is an open access active Ethernet fiber to the premises network designed to provide network connections from customers to various exchange carriers, Internet service providers, and other telecommunications-related service providers. The entire network is based on IEEE 802.3 compliant network hardware that ensures it is compatible with any manufacturer’s Ethernet equipment and that it will interconnect properly with various Ethernet switches and devices as well as support pass-through of other technologies. As opposed to other technologies which rely on proprietary hardware, the proposed network’s Ethernet-based design enables it to upgrade any link or device to higher speed and/or greater capabilities with industry standard Ethernet devices.

2.2.1.1 Dark Fiber vs. Lit Fiber

Implicit in the ability for the fiber to support the principle of servicing multiple service providers is the conclusion that the physical network owner needs to, in fact, light the fiber and provide the transport. If the physical network provider does not light the fibers of its network, then their infrastructure can only offer dark fibers. A dark fiber solution means that cities are involved only to the extent that fiber is deployed throughout the neighborhoods. In such a case, where the city fails to light the fiber and provide the transport, the supposed assumption is that by simply making a robust and ubiquitous infrastructure available, the benefits of the technology will also automatically be accessible. This logic fails to consider that whenever a city leases or sells fiber to a private entity, it essentially delivers a monopoly to that profit driven entity. Owning and managing the transport of goods and services across a fiber provides that monopoly stake holder with unmitigated control and allows it to exclude access to that fiber by any and all competition. The case of multiple dark fibers is not much better: the limit of the number of physical strands of fiber in the network means only a limited number of service providers can purchase access the individual end-users.

There is nothing inherently monopolistic in private ownership of a fiber, but history and logic both concur to suggest that the drive for competitive advantages persuades private owners to move in that direction. While multiple providers **could** conceivably use a privately owned fiber in a multi-dark-fiber environment, the market would be extremely consolidated and little true competition would exist.

Since one of the principles guiding municipal open access fiber to the premises is for abundant competition to deliver greater choice and better pricing, it is evident that municipalities, as the physical network owners, should light the fiber. This moves control over the natural monopoly infrastructure to the public owner whose motivation is to add as many competing service providers as the system can sustain, not to restrict access. Thus, by controlling and providing transport, cities can maximize the benefits of an open system.

This does not preclude a hybrid approach where some dark fiber is leased to some service providers and lit service is provided to other service providers. But since it makes sense for the municipalities to provide the transport as well as the medium, the next question raised is whether the infrastructure should be involved in any of the higher layers.

2.2.1.2 Standards

A valid starting point to help sort through the options is the question of whether the network owner should manage only at the photonic level or at a more granular cell/packets level. Photonic networking is considered to be the ultimate optical solution. The logic of pushing an all fiber network to an all optical solution makes a sort of romantic sense but it is difficult to operationalize when the vast majority of the edge equipment and devices expect some sort of electrical cell/packet interface.

An "all optical" network makes more sense in the backbone where the electrical interfaces have long evolved into straight optical interfaces. But even there the pure optical switch fabrics haven't yet taken over the electrical cell/packet switch/router control planes and switching fabrics. Since the business model for these access networks should be defined first and foremost from the perspective of the most common denominator, the residential consumer, then designing a solution based on pure optical networking would only generate higher costs to access the majority of the end-users. Perhaps a few service and technology evolutions down the road a pure optical networking solution will be more obvious.

Since an all optical network is impractical today, we are faced with the question of what cell/packet transport protocol is best. By appealing to the guiding principles, we are inclined to make that analysis based on the principle of standardization.

By referring to "Industry Standards," we can mean many things. There are different levels of standardizations, which include, in descending order of influence:

- ***Global.*** An example of a global standard is Ethernet. Available globally in a wide range of applications, an Ethernet interface is commonly found on most servers and PCs produced and Ethernet interfaces are even appearing on TVs and VoIP handsets.
- ***Industry.*** Industry standards such as ATM are certainly very common and accepted to their individual industries. And yet finding direct ATM interfaces on computers and televisions and VoIP telephones is very difficult.
- ***Consortium.*** Sometimes consortiums are formed to help create standards. Although consortium solutions typically do not lead towards a global standard, this is a path individual companies will take as they attempt to join forces with others.
- ***Proprietary.*** Proprietary standards are typically pursued when a specific company has discovered a novel solution. The value of the unique advantages such a solution may offer need to be weighed against the sole source environment.

The distinction between these standards is important because the farther down the chain one progresses from an open global standard towards a proprietary solution, the greater the impact on:

- ***Innovation.*** It is difficult to foster innovation in services and applications if the technology required for that innovation is locked up in a single vendor's proprietary relationship. Unless a researcher buys in to the royalties of the solution, they will not have access to the technology, thus stymieing product and service innovation.
- ***Cost.*** Cost is a well understood benefit of standardization. During an initial period of time when technologies are being developed, the cost of a solution is typically high as every effort, from design to manufacturing, is a customized one. Once a solution becomes a global standard, the cost of implementation drops as components become commoditized.
- ***Competitive options.*** When consumers have a choice between competitive offerings, prices stabilize at the appropriate competitive market level. The more vendors supporting a standard, the more the suppliers are pressured to compete to minimize costs.
- ***Interoperability.*** The more universal the standard, the greater the likelihood of interoperability between diverse solutions. Unfortunately, many vendors who claim to follow an industry standard find they are unable to interoperate with other vendors also claiming to follow the same standard.

- ***"Leading-edge" vs. Existing technologies.*** Leading edge technologies are sometimes developed for the sole purpose of creating a proprietary business model for a specific company attempting to develop a new standard. Often times these new technologies do not add a substantive improvement over the existing or established technologies - they are merely an attempt by a group of investors to capitalize on a growing market segment.

By examining the effect of each of these levels of standardizations it is easy to see that the more accessible a technological solution is to the global community, the more flexibility a systems operator will have. The technical position for municipal projects should be focused on global standards with a careful eye on new technologies which add a substantive evolution/revolution to the tried and true global solutions.

2.2.1.3 Why Fiber Over Other Physical Media

In addressing the needs for advanced telecommunications throughout a municipal open access network service area, the initial technical question requiring resolution is that of physical distribution medium. Which of the various technologies - copper, wireless, fiber, or others - adheres to the guiding principles and provides a solid foundation for the rest of the technological solution? Any one of the options provides some type of resolution but one choice becomes obvious - fiber. With one of the Principles being High Scalable Bandwidth, no other physical media comes even close.

2.2.1.3.1 Dedicated vs. Shared Access

Broken into dedicated and shared access solutions, the strengths and weaknesses of each solution (from a bandwidth perspective) are obvious. A quick look at the symmetrical bandwidth available for a neighborhood of a thousand homes reveals a profound difference.

Dedicated Access: Two technologies deliver dedicated connections: fiber and DSL.

- **Fiber's** 1,000 home throughput of symmetrical service is 1,000 Gbps based on an active Ethernet fiber deployment where customer connections are a full Gbps.
- **DSL's** bandwidth is theoretically 5.2 Gbps downstream and 1.6 Gbps upstream premised on the copper infrastructure being shorter than 4,000 feet in every instance.

Shared Access: Shared network solutions sound promising when the throughput is stated without taking into account the shared nature of the network. The reality is that the access is not only **intended** to be shared, it always **is** shared, yielding less than the maximum potential.

The primary problem with today's shared networks is that, for optimal speed and performance, they depend on unchanging end-user traffic patterns. The networks are designed to deliver optimal speeds based on pre-defined usage expectations. When usage patterns change – almost always resulting in usage increases – performance degrades. When hundreds of users initiate "always on" traffic patterns on these shared access networks, they fail to deliver much more than dial up speeds. As the availability of streaming video content increases, typical usage patterns will include more high bandwidth "always on" flows.

This will eventually create network engineering problems similar to those found in the historical changes experienced by the public switched telephone network. Class 5 switch engineers realized the inadequacies of their networks when dial-up modems exploded into people's homes. The shared trunk networks in the PSTN were vastly under-engineered for the uptime characteristics of that new "voice grade" application, resulting in people's inability to even make a simple phone call.

Both cable modem (coaxial cable or coax) and wireless systems are predicated on shared rather than dedicated access.

- **Coax** networks have difficulty supporting any sort of bi-directional data transmissions without additional infrastructure investment. Traditional cable deployments were purely copper based and disallowed bi-directional communications. Recently, an infusion of fiber to support these coax networks yielded operational and service benefits, including the

Consider the following analogy to illustrate the long term scalability of fiber: if a standard drinking straw represent dial up speeds (56K), then a pipe about a foot in diameter equals a 100 Mbps connection. Using the same scale, a Gigabit connection would roughly be a pipe one meter in diameter. The fastest commercial connections for a single fiber would equal a pipe about 35 meters in diameter and the theoretical capacity of a fiber would be represented by a structure over a half a kilometer in diameter - or as large as the Hoover Dam. Clearly, if we are using a one-foot diameter straw today, we have room to scale a network given the theoretical capacity of fiber.

The straw on the left represents the capacity of a dial-up connection; the one on the right, DSL.

Typical connections on fiber networks operate at 100 and 1,000 Mbps. The pipes shown illustrate those capacities relative to DSL connections.

Current technology can deliver terabits (1 million megabits) over the same strand of fiber.

The theoretical capacity of a single fiber is equal to a pipe the size of the Hoover Dam!

support of two-way data services. Unfortunately, the system upgrades were designed to squeeze in additional services on an already crowded delivery medium. Reluctant to sacrifice video bandwidth for internet use, most cable companies have allocated about 40 Mbps for data services for every node - that is, 40 Mbps to be shared among an average of 500 homes. DOCSIS 3 allows bonding of multiple channels – creating an environment where typically four channels are combined to provide throughput of 171.5 Mbps to be shared among the homes in the service area. Given enough distribution level fiber, notes can be split as traffic increases cutting service areas to about 250 homes. Thus, 1,000 homes would have access to 686 Mbps of bandwidth.

- **Wireless** solutions are marketed the same way as cable networks and have the same inherent drawbacks. WiMax is an excellent solution for a small user base with little to no other access options available. A throughput of 90+ Mbps sounds comparable to a fiber connection of 100 Mbps until consumers realize they are sharing that capacity with up to 1,000 of their closest friends and neighbors.

Ultimately, compression technologies and other advances will continue to improve traditional network infrastructures, however, fiber represents the best scalable bandwidth opportunity. Copper solutions could be re-deployed to deliver comparable speeds to fiber - but only if the single twisted pair were replaced with significantly shorter CAT5 cables. Coax networks could deliver the listed fiber speeds if the fiber nodes were pushed as deep as 25-50 homes and the whole RF spectrum on the coax was modulated with 1024 QAM. And wireless could approach the listed fiber speed only if every house had its own antenna - and its own fiber backhaul! Fiber is the only truly high-bandwidth and scalable solution.

2.2.1.3.2 Carrier Class Characteristics of Fiber

Appealing to the other guiding principles also leads to fiber as the obvious solution. For example, the carrier class characteristics of a non-metallic conductor such as fiber are far superior to copper based solutions, and even more so when compared with wireless:

- It is imperviousness to electromagnetic interference
- It is impervious to corrosion
- It does not "leak" radiation, or signals, so it is more secure
- It cannot be tapped without losing the signal, making it more secure
- It is not subject to weather disturbances
- It has no latency issues as some satellite-based systems do

And the list goes on.

2.2.1.3.3 Supporting Open Access Networks

Finally, with respect to municipal open access networks, the capacity of a fiber network supports not only multiple service providers but also current as well as future services without the physical network owner needing to mediate disputes due to an inherently scarce physical network resource. While copper and wireless may provide sufficient bandwidth for a single carrier delivering a single service to a small number of dedicated users, neither can accommodate the vast amount of bandwidth required by multiple competing service providers offering a variety of next generation bandwidth intense services. Clearly, the guiding principles suggest that only fiber provides the desired solution.

2.2.1.4 Active vs. Passive

A fundamental tenet of any conductor is that as long as the media is dedicated to a specific end-user, then the full capability inherent in that media can be accessed by that end user. This leads to the understanding that a fiber "from" the home should be carried into the network as far as financially reasonable before that fiber is then terminated at some transition or aggregation point, whether it is a passive optical combiner/splitter (in a PON environment) or an active electrical/optical switching device.

Many PON networks have been engineered with PON splitters deployed as close to the home as possible with the intent of minimizing fiber costs. While this logic does indeed save a few dollars per home passed during the initial deployment, it is short-sighted and may lead to scalability issues for the network in that it limits the deployment of electronics for future generations. And while the per-home passed cost is marginally reduced, a passive deployment actually increases the overall per subscriber electronics costs: unless every home on that edge split subscribes to services, the cost allocation of the OLT gear is over a smaller number of subscribers. In a typical, municipal competitive overbuild, take rates are less than the 100% assumption upon which the capacity of the PON is designed and the cost savings calculated.

A summary comparison of active vs. passive optical networks is in order here. In 2008 KEYMILE published a white paper titled "Ethernet Point-to-Point vs. PON – A Comparison of Two Optical Access Network Technologies and the Different Impact on Operations."[54] After describing the two technologies, KEYMILE presents the following technical comparison summary table (some spelling and terminology have been Americanized from the European spellings in the KEYMILE version):

	Active Assessment	PON Assessment	Comparison
Bandwidth Allocation	**Good** The bandwidth allocated to the subscriber is governed by the interface type, or by traffic shaping on the access node and is therefore adjustable in kilobit increments.	**Average** The GPON interface on the OLT today is 2.5/1.25 Gbps (downlink/uplink). The bandwidth per subscriber is determined by the splitting factor (usually 1:32 or 1:64). Modern PON systems allow bundling of several time divisions in dynamic bandwidth allocation; however the bandwidth in a PON segment is limited to 2.5 Gbps.	**Advantage Active** Because of its higher flexibility, active has a clear advantage. There are limitations in a PON network because only the segment bandwidth (2.5 Gbps) can be allocated to the subscribers.
Maximum Bandwidth per Subscriber	**Good** As all subscribers can be connected with their own fiber optics, bandwidth of between 100 Mbps and 1 Gbps (or more) per household or company can be achieved. Active fiber optic topology means that it is easy to use systems with even higher bandwidths for special applications.	**Satisfactory** With regards to today's GPON standards, the maximum conceivable capacity of a fiber optic equals the total capacity of an OLT port, i.e. 2.5 Gbps (active connection without splitter). Realistically the bandwidth with splitter and a division of usually 1:32 is 78 Mbps or 39 Mbps at 1:64 (all figures apply to downstream traffic).	**Advantage Active** In terms of bandwidth per subscriber, active enjoys a clear advantage. The maximum bandwidth per subscriber is a lot higher. The ability to allocate individual subscribers different bandwidths (e.g. in the case of business customers) is also more flexible than when PON systems are used.

[54] Keymile (2008). "Ethernet Point-to-Point vs. PON – A Comparison of Two Optical Access Network Technologies and the Different Impact on Operation". Keymile.

	Active Assessment	PON Assessment	Comparison
Bandwidth Increase	**Simple** As the active access nodes have modular structures, the subscriber interfaces can be upgraded to higher bandwidths. It is often sufficient to just switch the fiber optic cable to be able to operate it again.	**Difficult** Depending on the system's technology, several time divisions could be bundled and therefore increased by a factor of n + 1 at the cost of the maximum number of subscribers per PON branch. The bandwidth of the PON port on the OLT is the upper limit, i.e. 2.5/1.25 Gbps (down/up).	**Advantage Active** In this case, active architecture is superior to the PON's point to multi-point architecture. Just by adding boards, subscribers can obtain an upgrade, without the network architecture or the service of other subscribers having to be changed.
Effect of Malfunctions and Manipulation	**Low** Each customer has dedicated fiber optics. In general, wire tapping is not possible.	**High** A PON tree is a shared medium, i.e. the single fiber optic termination point. Data is separated by allocating the time division and encryption software. The setup is in the customer's network termination.	**Advantage Active** Similarly to WLAN, data in the PON network can be encrypted individually. Nevertheless it is possible to tap into another subscriber on the same PON tree and hack the encryption.
Reliability of the Subscriber Path	**Good** In an active network, a customer can be connected in a ring or by dual homing. In other words, a customer can be connected redundantly.	**Poor** To date, there are no plans to connect customers redundantly within a PON.	**Advantage Active** In terms of availability, PON is at a clear disadvantage compared with active.
Level of Sustainability for Connecting Large-Scale / Business Customers	**Very Good** Advantages such as flexibility, security and performance come very much to the fore. A router or switch can be used as an optical network termination to separate services.	**Poor** The customers in a PON tree are all treated the same. Customized requirements are only possible above protocol level 3.	**Advantage Active** Requirements from business customers are always special, PON network concepts tend to be more static. As a result, active architectures are a much better choice in this case.
Flexibility of Usage Regarding Optical Network Termination	**Good** Active Ethernet uses standardized Ethernet interfaces, a wide range of equipment can be used to terminate networks.	**Poor** Right up until today, there is no real interoperability between competing PON [vendor's equipment]. The operator is forced to purchase the ONTs and ONUs from the OLT supplier (creating dependency).	**Advantage Active** In this case, the operator of the active network can act more flexibly and exploit real cost benefits in the long term too (sustainability).

Table 2: Active vs. PON Technical Assesment

KEYMILE also provided a CAPEX financial comparison summary:

	Active Assessment	PON Assessment	Comparison
Costs of the Subscribers' Terminal Equipment (CPE)	**Average** Because standard Ethernet technology can be used. Today simple CPEs (e.g. Ethernet media converters) can be found for under $50 each.	**Average** ONTs are already produced in vast numbers but there is no compatibility between different manufacturers.	**Advantage Active** By using standard interfaces, active CPEs will probably have an edge on costs in future because of strong competition.

	Active Assessment	PON Assessment	Comparison
Costs of the Network Technology (Active Components, Fully Expanded Network)	**Average** Because each subscriber will occupy a dedicated laser port on the network node.	**Low** Because each port on the OLT will be shared by several customers as splitters are used.	**Advantage Passive** Because optical paths can be used by several subscribers, PON is a bonus as regards the price per subscriber.
Initial Investment in the Network Technology (Active Components, HC/HP 10-40%)	**Average** Only paying customers will be allocated an active port.	**High** Each optical splitter is connected to an active OLT port.	**Advantage Active** Only active customers have to be connected.
Space Required for Systems Technology	**Average** Numerous active interfaces have to be accommodated at the central site. However, the space required decreases with each new generation of active systems.	**Low** Little space required at the central site but the passive splitters have to be placed in the access network.	**Advantage Passive** At the central site, the PON requires less space.

Table 3: Active vs. PON CAPEX Assessment

Finally, KEYMILE provided an OPPEX financial comparison summary:

	Active Assessment	PON Assessment	Comparison
Energy Consumption	**Average** Because of the high number of laser interfaces energy costs are high. However, new systems achieve much better values than the last generation.	**Low** Because of passive splitting energy costs are low.	**Advantage Passive** Because of the passive splitter and greater subscriber density on the OLT, PON is better in this case.
Level of Difficulty in Identifying and Rectifying Faults	**Low** Because of the active topology and the dedicated optical transmission path many faults can be traced from the NMS.	**High** Because in the worst case scenario a faulty ONT cannot be localized by the NMS. A local visit to the customer is often required. Depending on how easy the ONT is to access, finding the fault can take some time.	**Advantage Active** Identifying and rectifying faults is much easier in active topology than in a PON. Nevertheless, analysis capabilities in a PON can be improved by using optional monitoring systems.
Follow-Up Costs for Upgrades	**Low** Because the active components have enhanced scalability and customers can be separated, customized upgrades can be carried out in the active network and the CPE can be changed.	**High** An entire PON tree is always affected by an upgrade. All ONTs have to be exchanged at the same time. As a result, individual upgrades are virtually precluded.	**Advantage Active** Because of enhanced customizable flexibility, active Ethernet has an advantage in terms of upgrade capabilities.

Table 4: Active vs. PON OPEX Assessment

For those keeping score:

- Advantage Passive: 3
- Advantage Active: 11

2.2.1.4.1 Reliability

In addition to interoperability, another criterion used to select technologies is the guiding principle of building nothing less than a carrier class network. Since reliability is at the heart of a carrier class network, municipalities should filter out those technologies incapable of providing a carrier class level of reliability – at least four 9's of up time.

There are aspects to reliability over which the network owner has no control, and then there are those over which it clearly does. For example: while the occurrence of "backhoe fade" (the cutting of a line by a backhoe) is out of control of the physical network provider, the **effect** of backhoe fade on the delivered services is dependent on the topology of the solution. "Figure 13: Active vs. PON Exposure to Fiber Cut Failures" shows that effect in different network topologies (the unprotected portion of a signal's path is indicated as a dotted line and the protected path as a solid line).

The potential reliability of the network should be weighed against ease of maintenance. While a passive topology may require fewer maintenance trips, there are few mechanisms available to identify where a fiber cut occurs and no mechanism to maintain connectivity when there is a cable cut in the distribution network. Inasmuch as fiber cuts are an inevitable fact of life, the analysis of system reliability depends heavily on an assessment of the impact of cuts.

Assessing the potential impact of downtime in a PON solution first requires an analysis of the failure group size per cable and the probability for the cable cut. By estimating both the frequency of cable cuts and the average number of subscribers affected per unprotected optical path, we can determine the impact of an inevitable cut. The larger number of unprotected subscribers carried on a PON solution near a hub makes the PON insufficiently reliable to be called carrier class. Applying the same rates for cable cut occurrences across all layers of the network; one can derive PONs have up to 10 times more unprotected optical path than a comparable active network.

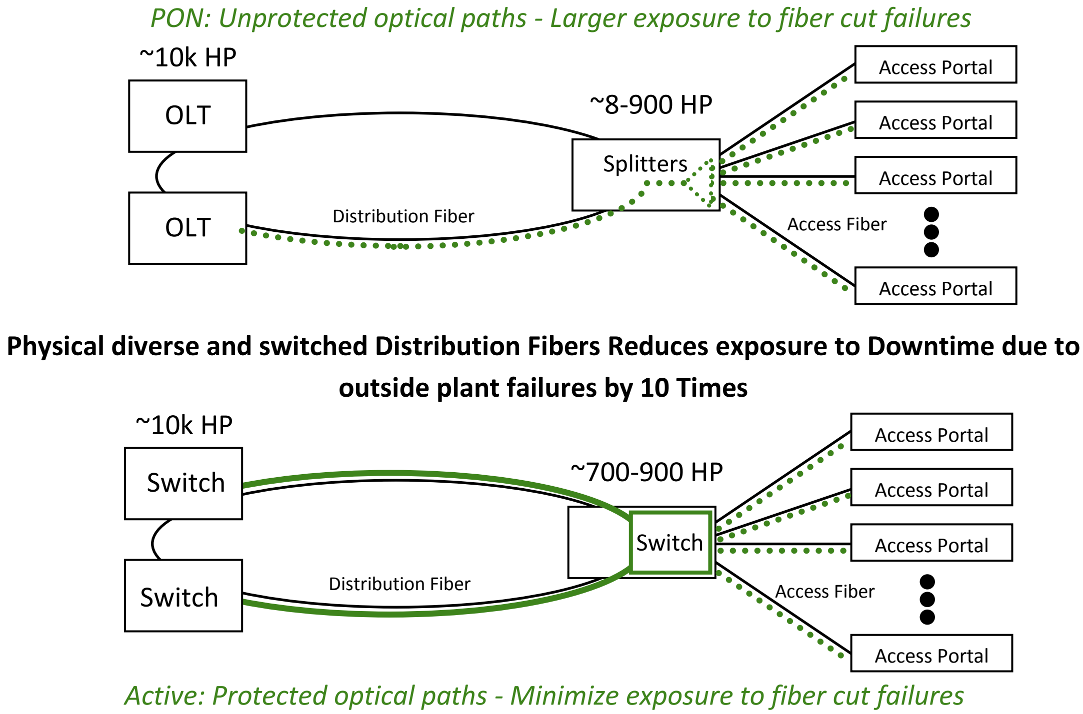


Figure 13: Active vs. PON Exposure to Fiber Cut Failures

HP=Households Passed

Therefore, it is expected that the cut rate/failure rate of a PON would be as much as 10 times higher than its active counterpart, thus further reducing its reliability even below the three 9's shown in "Figure 14: Maximum Limit to Availability Due to Fiber Cuts**Error! Reference source not found.**".

Maximum limit to availability due to fiber cuts

Single Homed No Diversity	Topology	Failure Group Size	Annual cuts per cables	MTTR (hrs)	Downtime per subscriber each year (minutes)
Access Cut	PON	96	0.0012	6	41.5
	Active	96	0.0012	6	41.5
Distribution Cut	PON	800	0.0012	6	345.6
	Active	N/A - Physically Diverse/Redundant Transport			
Maximum Availability	**Availability**				
	PON	**99.93%**	**THREE 9s**		
	Active	**99.99%**	**FOUR 9s**		

Figure 14: Maximum Limit to Availability Due to Fiber Cuts

2.2.1.4.2 Plentiful Bandwidth

Though fiber itself is capable of supporting incredible speeds, not all fiber solutions deliver equally on that promise - depending on the network architecture, the resulting available bandwidth can vary greatly. Some solutions start out with high bit rate optical speeds, but after those speeds have been shared across multiple end-users, the bandwidth that is ultimately available to the end-user is often no better than what is available to them today over incumbent copper based or wireless systems. To benefit from the potential of fiber, municipalities should identify which solution has the most bandwidth and the most flexibility in applying that bandwidth.

A simple analysis of some typical solutions for a 1,000 home neighborhood reveals some startling differences.

	Active/Dedicated		Passive/Shared		
	100 Mbps	**1 Gbps**	**OC3 APON**	**OC12 APON**	**1 Gbps GPON**
1,000 Home Footprint	100Gbps	1,000 Gbps	5 Gbps	19 Gbps	31 Gbps
Per User	100 Mbps	1,000 Mbps	5 Mbps	19Mbps	31 Mbps

Table 5: Active vs. PON Bandwidth Availability

This comparison obviates that an active solution is as much of an improvement over passive solutions as passive solutions are over existing DSL.

Even with the most rudimentary understanding of what a fiber network can offer, consumers understand that incremental improvements of bandwidth over what current solutions offer are not compelling - they expect a quantum leap in the speeds offered over a fiber network compared to incumbent solutions. We need look no further than the ill fated deployment of ISDN to see that consumers expect a clear differentiation in the offerings. Inasmuch as ISDN speeds were not substantially different from dialup, and given the greater speed offered by DSL, the incumbent phone companies abandoned ISDN deployments and moved into DSL.

Furthermore, the network owner should expect the network to have capacity sufficient for significant growth. Having invested so much in its system, communities should want to avoid additional, potentially expensive major changes to the network architecture or to the corresponding technologies to accommodate inevitable growth. The Active solution clearly offers the superior solution demanded of the high scalable bandwidth principle.

2.2.1.4.3 Cost to Scale

The next pertinent bandwidth concern to be considered is the cost to scale the selected solution. "Table 5: Active vs. PON Bandwidth Availability" demonstrates bandwidth in the access network. Since 90% of the money spent on transport technology is spent in the access infrastructure, and since it is so difficult to change out the edge of the network, it makes sense to place a great deal of emphasis on bandwidth throughput at the access layer.

It is generally acknowledged that APON solutions do not scale well; therefore, they do not satisfy the scalability requirement. Given their limitations, it is likely that the only evolutionary path for them is a complete replacement when increasing bandwidth needs exceed their capacities. GPONs, on the other hand, are more likely to evolve in the fashion that PONs were designed to be scaled. Over the next five years, the FSAN 984.x Gbps could see changes in the reinforcement of the uplinks and in the reduction of the splitter ratio. Still, a deployment of even a 2.5Gbps GPON solution split 32:1, delivering 80 Mbps of dedicated capacity per user falls short of the bandwidth of even a 100 Mbps Active solution.

However, having tremendous amounts of bandwidth in the access layer is of little use if that bandwidth cannot be passed on through cascading aggregation layers to the core network and its connection to the rest of the world. Small networks may have only a single switch bringing together the community and connecting it to the rest of the world, a larger network, a network with sufficient scale to make a municipal open access fiber to the premises project succeed, requires a relatively large core network to aggregate traffic from the edge and send it on.

In the initial deployment of the network, the access layers will not have reached capacity. The cost conscious tendency is to implement solutions that handle current traffic needs, ready to scale as need demands. As the use of the network increases, and as applications require greater amounts of bandwidth, the need for cost effective scalability becomes obvious. Therefore, an important consideration is the ability for the network to scale beyond its initial deployment to accommodate the robust core bandwidth requirements of a more mature network.

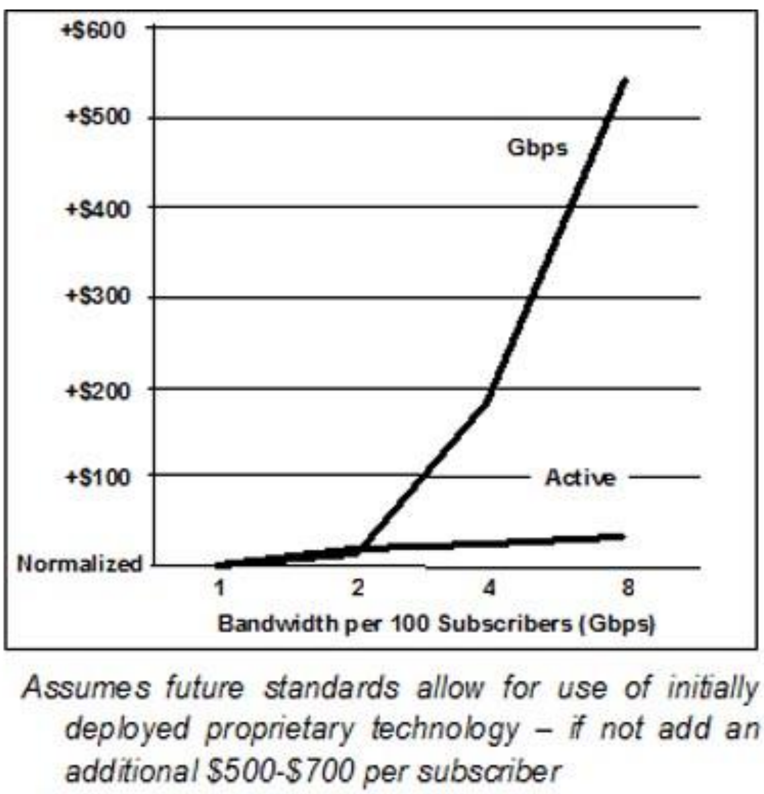


Figure 15: Active vs. PON Cost to Scale

To evaluate the different scaling costs of GPONs and Active solutions we will start with an initial bandwidth of 1 Gbps within the distribution network for every 100 subscribers. Each solution's cost will be tracked as the amount of bandwidth in the distribution network is doubled again and again. A comparison of cost and an evaluation of the convenience of the scalability between the two potential solutions present a compelling reason for choosing an Active solution over a Passive one. "Figure 15: Active vs. PON

Cost to Scale" shows how costs increase as the capacity of the network scales.

Besides being less costly to scale, the Active solution has the benefit of being very convenient, requiring nothing more than the addition of single mode GBICs. The GPON solution, however, can be problematic if, at the hub, the real estate is not sized to handle four times as much equipment (mooting the space advantage given by KEYMILE to the passive solution in "Table 3: Active vs. PON CAPEX Assessment"). Finally, because the GPON solution is still a developing standard in the industry and is not yet a global standard, it is not inconceivable that the standard could evolve, thus making future equipment incompatible with the equipment deployed today requiring a trade out of end-user equipment.

2.2.1.4.4 Open Access Support

Having determined that an Active solution best addresses the principles of high scalable bandwidth; carrier class functionality; and open and independent architecture, technology evaluators can address the last of the four principles guiding their selection of a municipal fiber to the premises solution: support for an open access network.

It is worth re-emphasizing that this principle may likely be the most important consideration for any municipal deployment. Publicly-owned advanced communications infrastructures only make political sense if they help the private sector to thrive. A properly formed public-private partnership frees the fiber infrastructure from monopolistic business practices and facilitates the growth and development of private, competitive market solutions, allowing private industry to flourish. Before selecting a technical solution that supports this fundamental principle, it is important to understand how services should be delivered over the network.

The primary function of the infrastructure is the delivery of data. To many, that means Internet traffic only. Though not always considered such, voice and video services are also, ultimately, data. In fact, anything that can be digitized and delivered over the fiber optic network is, in essence, data. The current vertically integrated model for voice and entertainment video is evolving and converging with other data services. Today, VoIP services are sold independently from the PSTN - and independent from the data provider itself. As we recall the way in which data service providers competed one with another through dial-up modems across the PSTN, we can envision similar competition and end-user flexibility as services delivered over the fiber infrastructure are separated from the infrastructure ownership.

Technically, services can be separated from the infrastructure quite readily. In fact the OSI model can be used to describe the demarcation point for the delivery of services. In the OSI model[55], layer 1 represents the physical media fiber, layers 2-4 embrace transport and networking, and layers 5-7 deal with applications. Today service providers typically provide network services at the IP layer (layer 3) and

[55] The image of the OSI model in "Figure 16: OSI Layered Model" is from the Computer Desktop Encyclopedia "OSI model" entry viewed 21 January 2014 at http://lookup.computerlanguage.com/host_app/search?cid=C999999&term=osi+model&lookup.x=49&lookup.y=21.

depend heavily on TCP/IP for the connections. It is an effective model, but it has the disadvantage of being at a minimum management intensive and perhaps even intrusive to the services delivered.

If the municipally run network is deployed utilizing routing protocols, it is likely that the services delivered through that infrastructure will not be transparent to the infrastructure. While it is certainly possible to design, deploy and operate a network that is based on packet handling through to layer 4, it is likely that services delivered in that way would be more limited than if those packets were transported only at layer 2. Ideally, a layer 2 network presents the greatest variety of options for the service providers and the least amount of management for the owner.

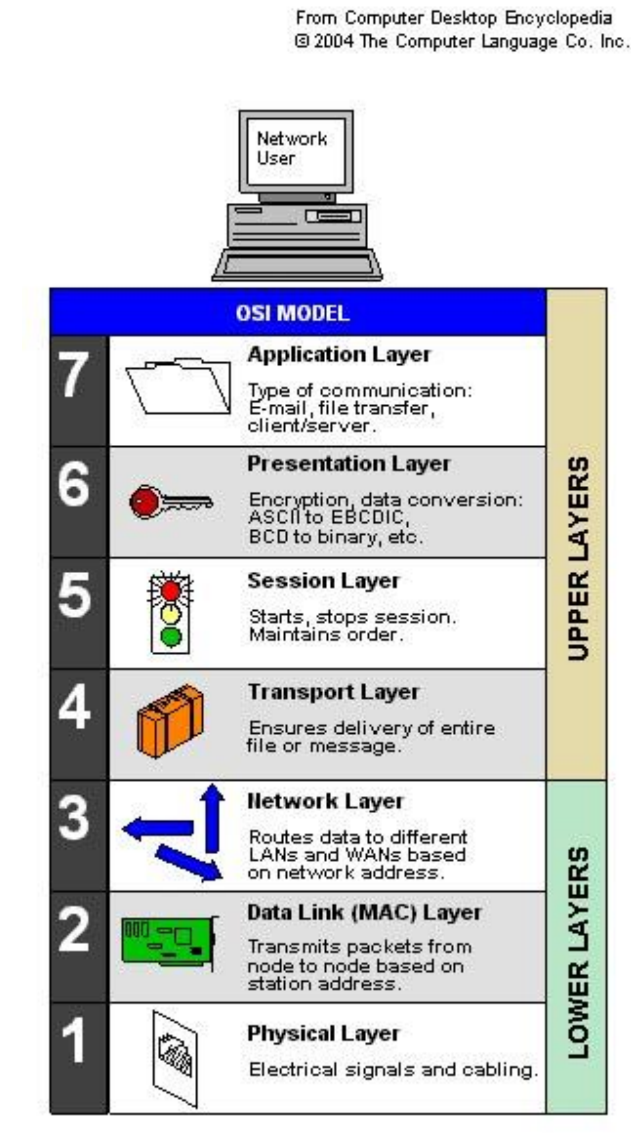


Figure 16: OSI Layered Model

Wholesale network services at layer 2 are very attractive to a municipal owned network from a variety of perspectives. Transparency to the retail service provider is more complete - but a transparency with respect to the popular hacks, viruses, and DOS attacks means the municipal owner can minimize its involvement not only in the retail products sold across the infrastructure, but it avoids the majority of the problems as well.

As anyone would, municipalities place more emphasis on solutions that will be functional for longer periods of time. Because layer 2 is inherently simpler, the likelihood of technological obsolescence is reduced. If the network is deployed emphasizing layer 2, changes that occur at layers 3 and 4 are more likely to be transparent allowing the investment in network technology to be relevant for a longer period of time.

An emphasis on layer 2 does not mean that the network operates exclusively at layer 2. In fact, an Ethernet network supplemented with MPLS introduces higher complexity, through layer interaction, than a strict layer 3 or 4 network would. Despite that complexity, the access network needs some ability to influence traffic handling at some of the higher layers than just layer 2. To protect the network and minimize problems, the network needs to be able to support some layer 3/4 filters along with ACLs.

The reality is that a complete layer 2 network would be characterized as one large broadcast domain. Without some simple filters in place, all broadcasts from all users would reach all of the other users in the network. Simple DHCP requests would end up looking for the nearest server to grant an IP address. In addition to DHCP filtering, NetBIOS filters would be essential, especially when such common functions, such as the sharing of a hard drive between Windows machines, would also have the unexpected side-effect of letting everyone on the network see those drives, whether that was intended or not.

Transparency to services does not mean traffic cannot be directed according to at least a high level set of needs. Traffic that needs to be isolated while traversing the network may be switched in a point to point service similar to the virtual tributaries found in a SONET solution. Point to point connections allow for services such as transparent LAN service to be delivered through the infrastructure. For applications such as voice over IP point to multipoint connectivity gives the isolation between end-users. For general connectivity, a multipoint to multipoint network provides the greatest amount of flexibility for connectivity through that VLAN.

Despite the limitations described, a network emphasizing Layer 2 still presents the best option for longevity, ease of management, and transparency to the service provider.

Even in a Layer 2 environment, the service provider may elect to offer higher level services to accommodate less sophisticated service providers and to enhance consumer choice.

2.2.1.4.5 Deployment Cost

It is easy to determine the cost per home passed for Active and Passive designs. In defining the terms, we can summarize by saying that if the switch which terminates the subscriber's link is within 2 km of the end-user, the solution is active. If the terminating port is shared among multiple users over 10+ km of outside plant, the solution is a PON. To minimize outside plant costs a PON solution implements a cascading splitter design with a 4 port splitter/combiner deployed near the end user and an 8 port splitter near an aggregation point relatively remote from the hub location which would house the terminating equipment (not more than 20 km from the most distant end-user). A relatively simple cost comparison between that solution and a solution designed to support a dedicated active solution demonstrates that the cost of the outside plant infrastructure to support a PON solution is less costly than an active solution by roughly $9 per home passed (see “Figure 17: OSP Cost Allocations per Household Passed”).

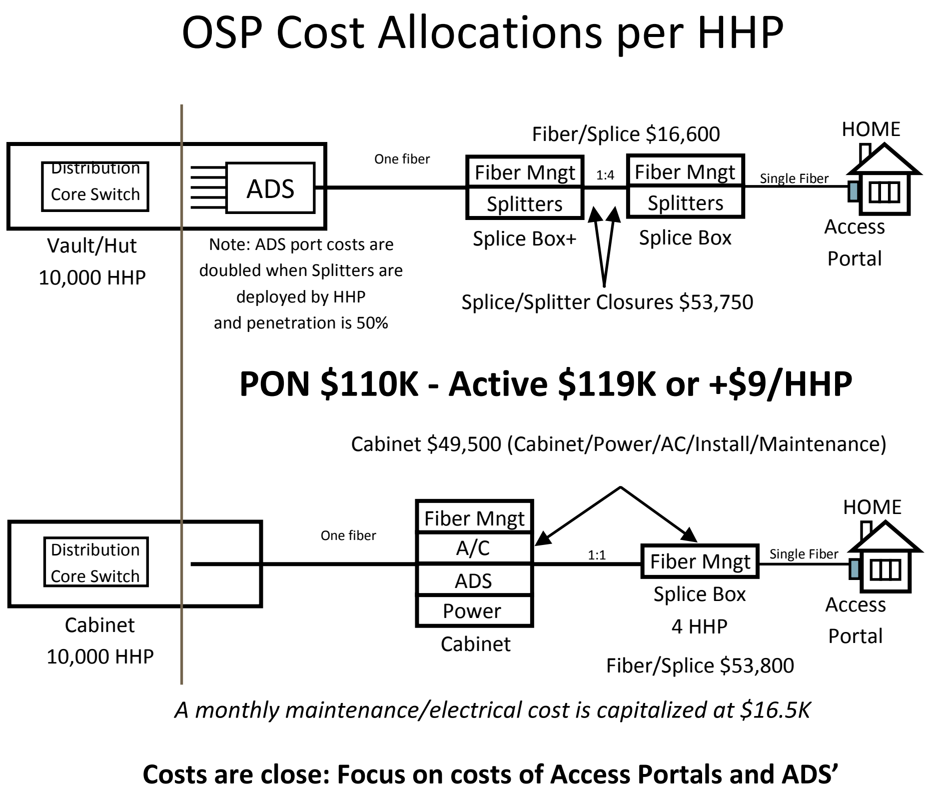


Figure 17: OSP Cost Allocations per Household Passed

Understanding the very close outside plant cost provides reviewers a key variable in comparing technologies and steers cost evaluations to the costs of access portals and other electronics. By averaging typical cost efficient vendor solutions, we see:

	Cost Advantage: Active over PON
Outside Plant	(-$9)
ADS (OLT)	$189
Access Portal (ONU)	$408
ACTIVE Savings	**$589**

Table 6: Active vs. Passive Deployment Cost

The cost difference inherent in the outside plant solution for the PON is completely overshadowed by the difference of the cost in the electronics. To extend those saving out over the entire project, a $580 savings per subscriber for the dedicated active solution is likely to reduce the cost per residential subscriber by nearly $15/month.

It is likely that as both the proprietary and the more standard PON solutions become more prevalent, the cost of those solutions will go down. As for Ethernet - since the global standard for 100 Mbps and Gbps solutions has already experienced a steep cost reduction, it is more likely that the next level of significant savings will focus on next generation dedicated active solutions.

2.2.1.5 Outside Plant Design

In competitive overbuild scenarios the need to defer complexity and cost to as close to revenue generation as possible dictate that network construction end at the property line of potential subscribers except in instances where above 60% take rates are expected. In other words, drops are deferred and fiber will be placed up to, but not beyond, the property line for each residence and business. In this scenario, sufficient quantities of fiber are deployed in each area based on the anticipated maximum take rates and adequate relief plans are in place to accommodate the happy accident that success exceeds planned results.

In network deployments where some technology or policy need drives 100% connectivity at the time of initial construction fiber counts are deployed to accommodate 100% connectivity and network design includes drop level architecture.

To reduce the cost of construction, the access and distribution network is run predominantly up one side of the street only, with a lateral crossing the street at reasonable points. During initial construction phases, these laterals are left as empty conduits (unless some technology or policy need drives 100% connectivity at the time of initial construction), connecting the subscriber splice box to a lateral pull box. During engineering, engineers track the number of network splices per subscriber splice box: if it turns out that the design requires substantially more than one splice per home passed, the design is likely more costly than necessary and it is revised.

In the deferred drop model, when a consumer requests services, a conduit is placed between the lateral pull box and the new subscriber's premises. The drop fiber is then spliced at the subscriber splice box and pulled (through the lateral pull box if across the street) to the home for connection to the interior electronic termination point known as the customer premises equipment (CPE) or the access portal (AP).

2.2.1.5.1 Redundancy

The next consideration in architecting the network examines the value/requirements of single vs. dual physically redundant fiber paths to each end point. If there are two paths the fiber can take to get to the end user, then the reliability of the solution increases - but so do the costs. An appeal to the guiding principles leads municipalities deploying next generation broadband networks to a determination to provide redundancy in all layers of the network down to, but not including, the home run.

A typical analysis of potential revenue opportunity, construction costs, and the frequency of outside plant cuts, usually suggests that the extra cost associated with providing a redundant path to every end-point exceeds available revenue streams. More specifically, under current market conditions, physically diverse paths to most businesses could be offset by projected business revenue, but redundancy to support residential services could not. Further, business premium rates are likely to diminish through time as deregulation eliminates arbitrage opportunities making long-term dependence on premium business pricing unrealistic.

The distinction between business and residential customers is not always determined by zoning: businesses will co-exist with private residences in many areas. Certainly with the advent of the Internet almost anyone with the desire to develop a website could also develop a work-from-home economic model. In point of fact, open access fiber to the premises encourages more work at home and home based businesses. This means that plans for what are traditionally viewed as "residential neighborhoods" must allow for the inclusion of redundant fiber runs to home-based businesses - both now AND in the future. Rather than attempting to deploy redundancy to all addresses in the initial design, it is important to be able to add access and drop level redundancy as customers demand it (and as they are willing to pay for it).

2.2.1.5.2 Strand Counts

An additional question that needs to be answered is how many fibers should be taken from the different physical locations back into the network. For a typical residence, a single strand of fiber is sufficient. This conclusion is supported by the understanding that a single strand of fiber has over 150 Tbps theoretical carrying capacity, and that photons are unlikely to interfere with each other through nonlinearities in the fiber over the relatively short FTTP distances. Businesses, MDUs, and MTUs may require, in some cases, not only redundant connections, but also multiple fibers to service their needs. To accommodate possible redundant connections and multiple fibers to certain units, network designs should be designed with fiber counts to address immediate needs and with relief plans to ensure the ability to meet future demands.

2.2.1.5.3 Optimal Fiber Aggregation

After evaluating some basic decisions as to how the outside plant should be structured, the cost associated with deployment must be considered. Since construction costs are the single largest capital expenditure component of a municipal open access fiber to the premises implementation, a careful analysis of the impact that design has on construction costs is critical.

The goal for a proper outside plant analysis is to gather and analyze information on all of the pertinent material, components, and labor costs related to both aerial as well as underground deployment. Such an analysis should identify the most cost efficient location to terminate the dedicated fiber strands and to implement fiber sharing technology. In other words, how many homes will be serviced by a single aggregation point, or community cabinet (determining the optimal fiber aggregation point or OFAP)? The OFAP approach has been applied to various network deployments for quite some time, including design work to support digital loop carrier deployments, fiber node placement for HFC, and in the WINfirst FTTP deployments in Sacramento and Dallas where the OFAP technique was used to layout the most efficient fiber aggregation cabinet sizes and locations.

In the analysis, it is important to note that costs for construction vary not only region by region but city by city and even neighborhood by neighborhood. The primary variables affecting construction costs are related to the density of homes/structures per constructed mile and the type of construction required - either buried or aerial plant. Because of constant variation in costs, the optimal engineering design needs to be flexible enough to adjust fiber routing and aggregation strategies during engineering. As service areas are outlined and as the outside plant design gains detail careful consideration and reconsideration of the OFAP must be taken.

2.2.1.5.4 Distribution Network

Identifying the Community Cabinet location where each of the dedicated access fibers terminates allows the design of the distribution network. Since the fibers themselves will be functional long after the debates over active and passive have been settled (or at least until they have cycled back and forth a few times), the distribution fiber should be deployed with thought given to the carrier class principle. In other words, even if a PON design is chosen for today, the design should support the possibility of conversion to an active design as future needs dictate.

The most obvious approach should be to deploy physically diverse redundant paths from these access nodes back through to the core nodes. This distribution network, which connects the dedicated access plant from the community cabinets through to the hub locations, should have a fiber count based on the type of access technology chosen today: one fiber for every eight homes passed for a PON and one fiber for every thirty to fifty homes passed for an active solution. However, in the case of a PON, by splitting the fibers (normally deployed single threaded) over two physically diverse paths, the outside plant can support both a PON deployment today and be prepared to implement the higher reliability inherent in the physical diversity of an active deployment in the future.

2.2.1.5.5 Access Portals

Despite commonalities in these areas among certain available solutions, aspiring network owners should evaluate the interaction of different vendor solutions across each layer. During this evaluation, an interesting debate presents itself: where to place the customer premises equipment that terminates the fiber connection (the access portal or AP). Should it go inside or outside the premises?

Different deployments across the country show that both are reasonable options - it's really a question of balancing trade-offs. Placing the AP indoors leads to questions of ownership and liability, maintenance access to equipment, and so on; placing it outside leads to questions about security from tampering, protection from the elements, and so on. Ultimately, the additional cost of hardening the enclosures for outdoor placement seems a greater concern than an indoor placement with less access.

2.2.1.6 Logical Network Considerations

As with all other key decisions, municipalities implementing open access networks must select transport layer topology through an appeal to the guiding principles. To discover what options exist, aspiring network owners may solicit proposals from vendors through a public procurement processes or other means.

Recognizing that many solutions could, in some way, address the needs of an open access implementation, reviews of potential solutions should focus on the guiding principles - particularly the principle of open and independent standards - as the defining criteria for evaluating the options. Not surprisingly, most available technologies support the global Ethernet standard. Another smaller set of potential solutions support industry standards rather than global standards, many focus on the G.983 standard. Finally, another grouping of similar solutions included vendors supporting FSAN's G.984 GPON standard.

As might be expected, vendors offering anything other than the Ethernet or SONET compliant solutions are unable to commit to interoperability - even those compliant with the industry standards. Even though the FSAN standard has been under development for quite some time, few vendors can propose solutions using that standard that can provide a list of other vendors with whose solutions theirs were compliant. The other common industry standard, SONET, has vendors who were, in fact, interoperable. Of course vendors representing unique solutions or solutions based on the developing GPON standard were unable to commit to any kind of interoperability whatsoever. Clearly, in appealing to the guiding principles and by committing to adopt solutions that supported open and independent network standards, only vendors offering Ethernet solutions, with dozens of interoperable respondents, made sense.

2.2.1.6.1 Traffic Management

The guarantee that services can be delivered in a carrier class manner is affected by more than cable cuts; it also requires sufficient bandwidth and traffic management capabilities. Network designs should be scrutinized for traffic management support, including the ability to manage traffic flows in a sufficiently granular fashion to preclude one service provider's services from over-riding or interfering with another's. ATM and SONET have been designed with significant traffic management capabilities. With their deterministic cell and pipe characteristics, these protocols excel at traffic management and isolation. SONET is a bit less flexible; the lowest level of granularity for traffic management is by definition a virtual tributary, but SONET vendors offer a mix of Ethernet and ATM interfaces complete with switching fabrics with their products.

Native Ethernet has had the ability to identify or tag different types of traffic, but it was not expected to scale to city wide proportions and certainly not to provide bandwidth management. However, supplementing Ethernet with the standardized implementation of MPLS and label switch paths allows for the utilization of predominantly switching protocols to provide connectivity in a reliable and managed fashion without intruding on the service provider's quality of service management techniques. Prior to employing MPLS, Ethernet access infrastructures utilized ATM core switches or even SONET to ensure traffic handling characteristics suitable to maintain availability of services. Today, Hierarchical Virtual Private LAN Services support scalability, and Ethernet access infrastructures can be aggregated through MPLS core networks to allow for the entire pertinent network characteristics required: availability, bandwidth, packet loss, latency, and jitter.

From the perspective of traffic management, then, there may be no clear differentiator: ATM, SONET, and Ethernet/MPLS all addressed the need for reliability as it pertains to building a carrier class network.

2.2.1.6.2 Scalable Bi-directional Bandwidth

Inasmuch as there is no practical difference in the reliability of managing bandwidth among ATM, SONET, Ethernet/MPLS solutions, the availability of high, scalable bandwidth itself remains as an area of prime differentiation.

Included in the principle of high scalable bandwidth is the requirement for symmetrical transmissions. Examples of networks that follow an alternative logic are the hybrid fiber coax networks deployed by the cable companies. The HFC networks which were initially engineered with the assumption that the download usage would be roughly 17-19 times that of the upload, do not provide symmetrical transmissions. This assumption may have been the result of the cable industry's focus on their previous pure broadcast model, or it could have come about due to the belief that most people would be satisfied with browsing and downloading from the internet while only a select few would actually generate content to push. Shortly after these networks were deployed, capacity planners began to see download to upload ratios much closer to 3 to 1 rather than 17 to 1.

Today, the internet has become a network for interactive communications. A predominant value of the Internet is its ability to bring people with similar ideas together and to create virtual communities around real communities or common interests. These groups interact through their web pages, blogs, instant messaging, voice services, video conferencing, email and other bi-directionally intensive methodologies. Their interaction, however, is limited to what their bandwidth supports, and this is proving to be a growing source of frustration for many. In recognition of the growing need to push information out to the Internet in an interactive fashion, any practical solution to the demands of building a network with high, scalable bandwidth should include symmetrical high-speed transmission.

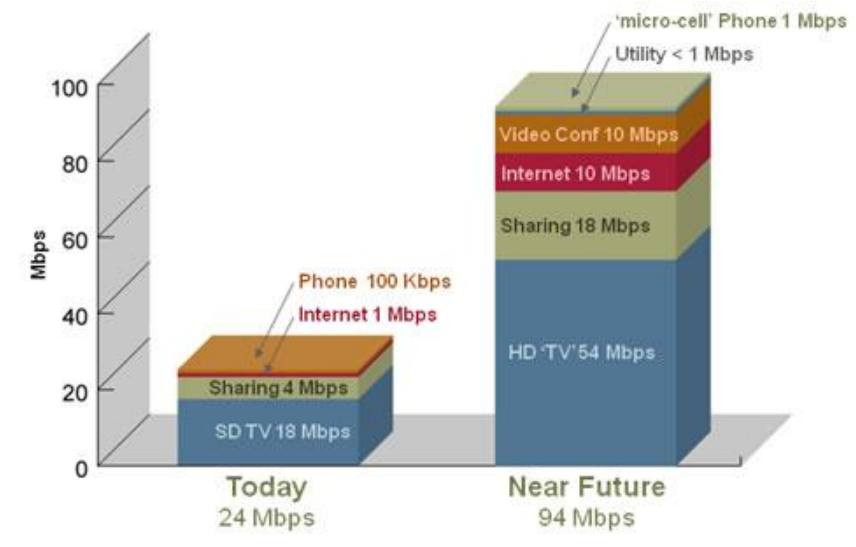


Figure 18: Near Future Bandwidth Requirements

Bandwidth needs are projected to continue to expand as capacity is provided for expansion. “Figure 18: Near Future Bandwidth Requirements” shows today’s bandwidth needs compared with projected needs in the near future.

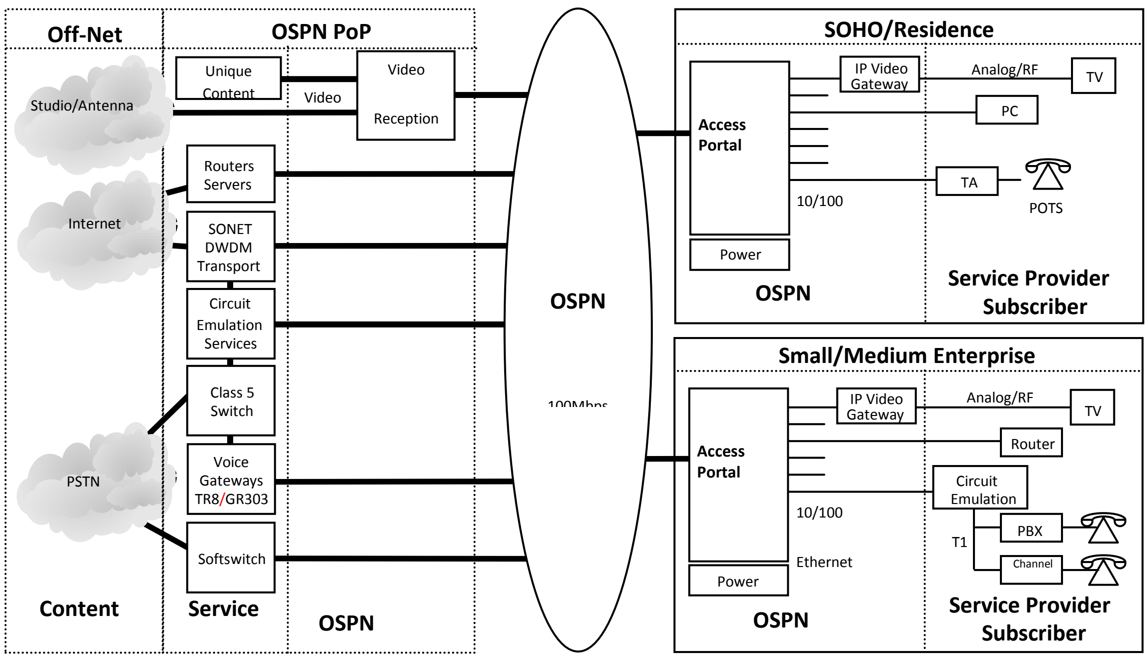
2.2.1.6.3 Network Interfaces

A Layer 2 Ethernet infrastructure is very well suited for native data applications. Since most applications are already designed to accommodate Ethernet's dominant global standard for data interfaces, the network needs offer just a couple of options to support the bulk of these applications:

- The Access Portal (or AP) represents the media conversion point, and traffic mapping interface, for data applications.

- Optical Interfaces may be required for more sophisticated businesses, both via multimode as well as single mode fiber. Those interfaces can be handled directly off of the OSPN access distribution switches.

Other standard applications, such as telephony and voice, should not require end-users to change their telephony device. To overcome the need for specialized equipment a terminal adapter could be deployed by the service provider. “Figure 19: Network Interfaces” illustrates the applications interface.



- Data Services interfaced via standard CAT5 and optical Ethernet
- Traditional POTS/T1 services through terminal adapters
- Video received into IP Head-end and through video gateways

Figure 19: Network Interfaces

As with voice and telephony, video-based services should not require end-users to upgrade all of their equipment to support a digital data only delivery mechanism. Using video gateways in the premises to convert and deliver standard video signals to existing TVs and receivers, the network can control ingress and egress of traffic and still remain open.

Service providers benefit from these common interfaces as well as end-users. If a retail service provider was required to build a head-end, integrate the middleware and digital rights management and purchase and deploy their own residential video gateway, then the barrier to enter the video market on the municipal network would be too high for all but the most resource rich providers. By integrating these functions, based on global standards, into the design and scope of the municipal open access fiber to the premises network, content providers who do not have any interest in those facilities can still be able to deliver services to the end-user.

The decision to incorporate certain services layer functionality demonstrates an open access network's engagement in ensuring an open and competitive environment across the shared infrastructure. By no means should a network owner prohibit resource rich providers from deploying their own head-end or other facilities based services. However, the economic development and other public policy interests of the project may drive owners to extend service availability to a larger number of competitors.

2.2.1.6.4 Capacity Management

As stated before, the correct operations model is more important to the success of a municipal network than is any particular technology decision. Once an operational model is selected and the technology has been chosen and deployed, the business of asset management, and in particular capacity management, becomes the architect's primary focus. With the utter failure of the mystical, metaphysical, and alchemical industries to deliver a working crystal ball, most engineers find they are only able to guess at the actual demands and performance of the network or determine how the infrastructure is going to behave with the deployment of advanced services. Using imagination and a good spreadsheet, planners can make a few basic assumptions to illuminate the potential capacity issues infrastructure might experience.

An overview of a typical municipal deployment covering roughly 200,000 homes shows the four main paths along which traffic will flow through a cascading aggregation topology.

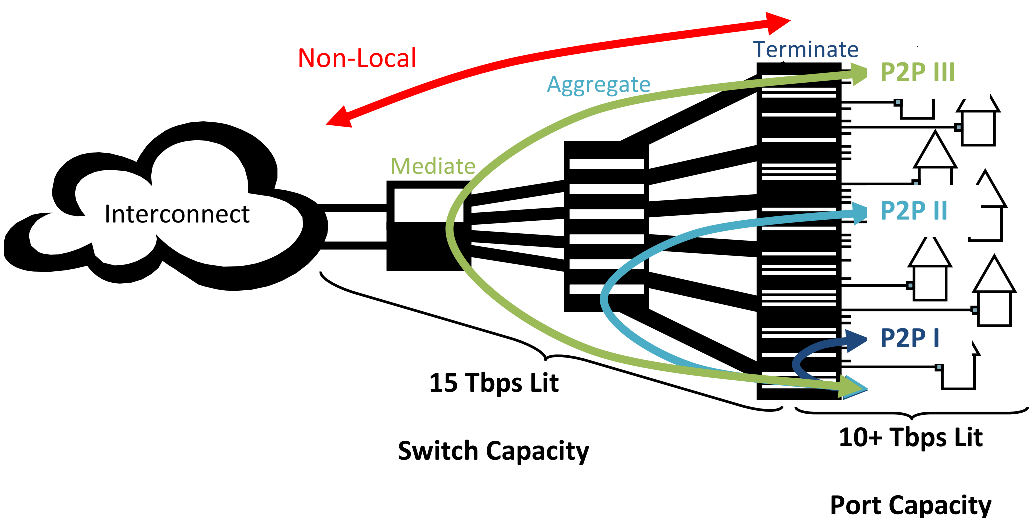


Figure 20: Cascading Aggregation

Terminate traffic or P2P I traffic is localized within a given footprint (about 900 addresses or 360 subscribers at a 40% take rate) and is limited primarily by the port speed and the ADS device backplane.

Aggregate or P2P II traffic is between devices within a community (up to about 30,000 addresses or 12,000 subscribers at a 40% take rate) and is limited by distribution ring capacity and the DCS devices.

Mediate traffic or P2P III traffic is between devices anywhere on the network and is limited by core ring capacity and the performance of the RCS devices within the distributed core.

In order to fully capitalize on the traffic management properties of cascading aggregation (to achieve the traffic patterns depicted above) and maximize the network's capacity for future services, service provider peering must be in place. Without service provider peering, a device from one resident service provider's customer communicating with a device from another resident service provider's customer must traverse all levels of cascading aggregation, leave through the one service provider's interconnect, re-enter the network on the other service provider's network and again traverse all levels of cascading aggregation thus behaving as non-local traffic. Implementing service provider peering will:

- *Mitigate Cascading Aggregation Point Traffic*. Without service provider peering all inter-service provider traffic must traverse the entire network. This requirement forces unnecessary traffic onto the aggregate, mediate and non-local levels of the cascading aggregation model.
- *Reduce Service Provider Interconnect Costs.* Without service provider peering all inter service provider traffic must flow through both service providers' interconnect points. Most service providers pay for their interconnect in steps based on the amount of throughput they require. The more services they can provide their customers "on net," the more manageable their interconnect costs become.
- *Encourage High Intensity Bandwidth Application Development.* Without service provider peering, high intensity bandwidth applications are loosely limited in availability to only the developing service provider's subscribers. With service provider peering, the potential user base for high intensity bandwidth applications opens up to all fiber subscribers. The larger user base should help encourage development of distinct high intensity bandwidth applications.

Service provider peering does not come without its challenges. Nonetheless, the advantages are great.

One method for analyzing capacity is to break potential services into three groups: existing, imminent, and possible. Each service should be given defined characteristics that allowed a general impact assessment on the network. The typical usage cycle, bandwidth required, and traffic connectivity (point to point and level of locality) are sufficient to discover some relatively obvious conclusions.

Advanced services are defined only for the purposes of stressing the network resources. An analysis can be performed by network layer to discover which layers would need reinforcing based upon various services mixes and associated traffic patterns. By introducing different scenarios of service penetration evaluators get a sense of how the links between the layers in the network are stressed beyond their initially planned levels.

As results of an analysis are reviewed, evaluators will note that the bandwidth available on the dedicated link to the home, with only one subscriber sharing that link, is the least likely portion of the network to fail. Typical service penetration scenarios will show adequate capacity. Evaluators will most likely conclude that the most difficult part of the network to change - the portion deployed to every end point - will be the last part of the network to require an upgrade. As would be expected, the more subscribers that share the network resources, the more likely it is that that portion of the network will require the deployment of additional, more advanced technologies. Evolving the connections between switches in the core of the network from a 20 Gbps link to an equivalent of a 200 Gbps link is likely to be the most important evolution after the initial deployment of the network resources has been accomplished.

2.2.1.7 Design Overview

The preceding sections have detailed design considerations and probable results of those decisions. Let's now turn our attention to an overview of what the preceding discussion will look like when deployed.

2.2.1.7.1 Physical Components

"Figure 21: Conceptual Network Overview" provides a graphic representation of the network's architecture.

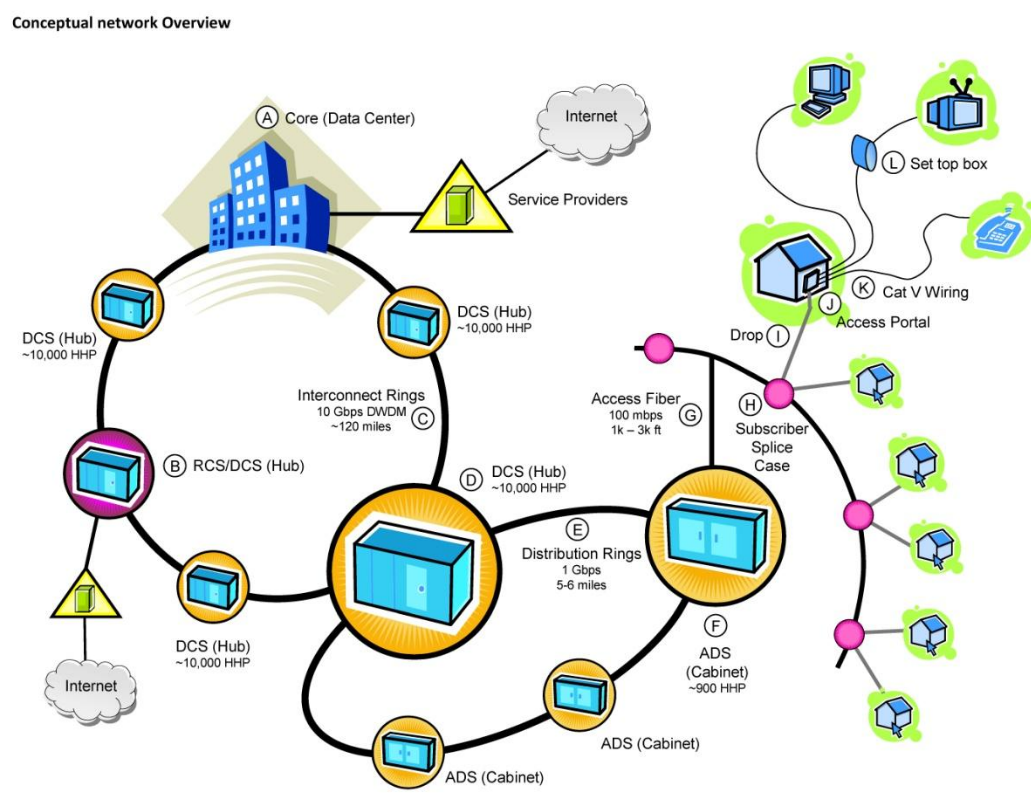


Figure 21: Conceptual Network Overview

The conceptual overview presents the following elements:

A. Core (Data Center)
   The network core consists of Regional Core Switches (RCS) located in regionally diverse locations. They are interconnected with 10GigE interfaces (as many as needed to accommodate traffic). Each

is connected to at least two other RCS devices so that if any RCS fails or loses connectivity, the core network is able to operate without interruption. Regional Core Switches (RCS) can be Alcatel 7450 ESS-12 switches or similar devices.

Service providers inter-connect with the network at any of the RCS or DCS sites and may also co-locate their routers and switches that they use to interface with the network connection at these locations. The primary interface for a service provider is typically a GbE port. Service providers in some cases interconnect in multiple locations, and are encouraged to do so for redundancy and capacity.

B. RCS/DCS (Hub)

To ensure geographic diversity and minimize expense, some RCS devices are installed at regional hubs instead of in carrier hotel data centers.

C. Interconnect Rings

The architecture uses a model of cascading aggregation to help ensure reliability and to provide optimum traffic management. Interconnect rings connect non-contiguous network areas making the regional nature of the network transparent to retail service providers. Core rings connect the multiple RCS devices to each other. Interconnect rings and core rings are often times parallel each other.

D. DCS (Hub)

Distribution Core Switches (DCS) are placed in each distribution hut or co-location facility and are used to aggregate distribution connections from one or more regions. These devices can be Alcatel 7450 ESS-7 switches or similar devices. They are installed in pairs and each connects back to a separate RCS with 10GigE on physically diverse fiber paths. The pairs are also connected to each other with 10GigE to provide a redundant path in the case of an upstream failure for one of them. Smaller DCS devices (Alcatel 7450 ESS-1 or similar devices) are used as a Point-of-Presence (POP) in data centers and co-location facilities to provide service provider, exchange carrier, and other interconnects in strategic locations.

E. Distribution Rings

Distribution ring architecture is the next level of cascading aggregation within the physical network. Distribution rings connect multiple cabinet sites (with their ADS devices) to the hub sites hosting their parent DCS devices.

F. ADS (Cabinet)

Figure 22: Alcatel OS-6400 an ADS Device Candidate

The project area is divided into a number of geographic areas of approximately 900 potential homes and businesses. We refer to these geographic service areas as footprints. Within each footprint is a single community cabinet that houses Access Distribution Switches (ADS) that serve all of the subscribers within the footprint. These ADS devices are connected back to the nearest DCS pair with two GbE connections (one in each direction on the physically diverse distribution fiber ring) that provide physical path redundancy to each ADS. Additional GbE connections are added as additional bandwidth is required. The ADS device may be an Alcatel OS-6400 or similar device. The ADS devices provide Fast Ethernet 100Mbps and 1GbE connections to each customer and aggregate those connections together to multiple GigE uplink connections.

10 GbE and higher capacity is also available from the community cabinet.

G. Access Fiber

Access fiber distributes the network from a community cabinet (ADS device) to the individual subscriber addresses.

H. Subscriber Splice Case

Until an address subscribes to service, the termination point for the potential customer is the subscriber splice case, also known as a customer access point or CAP. The subscriber splice case is a specialized splice point. All CAPs are splice cases but not all splice cases are CAPs.

I. Drop

Drop level infrastructure extends the network from the subscriber splice case to the premises demarcation and is placed when an address subscribes to service.

J. Access Portal

Figure 23: Allied Telesis iMG606BD – an Access Portal Candidate

The Access Portal (AP – referred to as and Ethernet Demarcation Device (EDD) or Optical Network Terminator (ONT) on some projects) in the proposed network serves as the demarcation point to the service provider's customer. This device is configured by the network manager as requested by the service provider. Typically configuration involves a port for the service provider's data VLAN, a port for their voice VLAN, and four ports for the service provider's video VLAN, with appropriate rate limits and prioritization for each type of service. This model allows a customer to obtain services from multiple service providers simultaneously using the same fiber connection in any combination supported by their 100 Mbps or 1 Gbps connection. The service provider is then responsible for the customer premises equipment (CPE) (i.e. IPTV set top boxes, phone adapters) and services that are delivered to the customer. The network manager provides a granular interface to the AP for service providers that includes link-state information, VLAN configuration, MAC address table, traffic statistics, and other useful information and allows for basic troubleshooting by the service provider's technicians.

The AP can be an Allied Telesis iMG606BD or similar device. The Allied Telesis features six customer-facing 100 Mbps full duplex Ethernet ports. Because the planned network is based on IEEE 802.3 standards, virtually any Ethernet based AP with appropriate interfaces and capabilities for VLAN tagging, rate limiting, etc., will integrate properly and can be used for this function. Each AP is also connected to an Uninterruptable Power Supply (UPS) with a minimum 4-hour life. The CPE and UPS are typically mounted inside the home in a utility room or near the telephone demarcation.

K. CAT5 Wiring

Services are distributed within the home via CAT5 wiring or through some conversion methodology that allows IP based services to function on another existing media.

L. Set Top Box (and other CPE)

IPTV services are converted for use on televisions through the set top box or STB. Voice services are converted through a terminal adapter or TA. Other advanced services (like medical monitoring and home security services) will require additional customer premises equipment or CPE.

2.2.1.7.2 Logical Components

The Core and Distribution network is configured in a Multiprotocol Label Switching (MPLS) mesh. This MPLS mesh creates a cloud where Virtual Private LAN Services (VPLS) are configured as point-to-point, point-to-multipoint, and multipoint-to-multipoint network circuits. A service provider interconnect is configured with multiple point-to-multipoint connections (one each for Data, VOIP, Video, etc) to their customers. At the DCS-ADS connection, the VPLS service has an exit point where the traffic is encapsulated into the specific VLANs for that service providers services. The services then traverse these VLANs to the AP, where it strips the VLAN tags and delivers the services, untagged, to the customer facing ports. The result is that the service provider is provided with a layer-2 tunnel per service, to each of their customers.

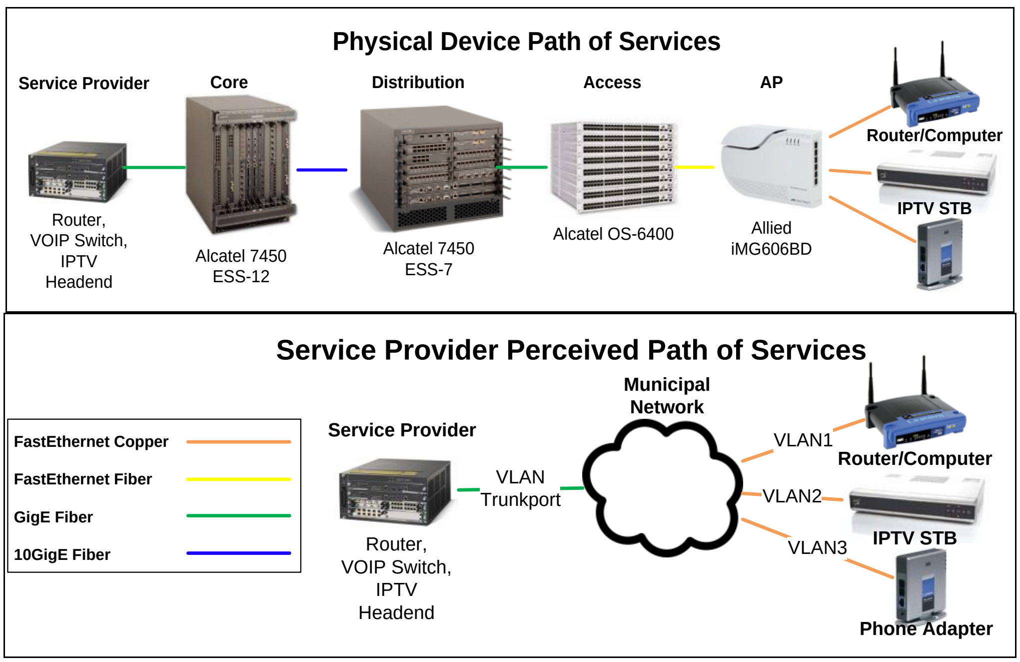


Figure 24: Physical vs. Logical Service Paths

2.2.2 Gigabit Network Requirements

Only active Ethernet gigabit open access fiber to the premises networks provide an open network architecture that allows for multiple service providers and equal access to fiber infrastructure at reasonable wholesale cost, providing dedicated bandwidth to all customers and service providers and is sufficient to support the provision of any combination of voice, video, and data services at gigabit speed, in both upstream and downstream directions.

2.3 Public Assets and Infrastructure

We understand LMG possesses a variety of public assets and infrastructure that may be leveraged to support the development and expansion of a comprehensive telecommunications network. Our proposed public-private partnership with public ownership of a wholesale fiber to the premises network has some impact on the potential utilization of these assets. Utilization of assets will depend heavily on the organizational structure.

3 Supporters of the Project

The RFI indicates LMG has discussed broadband development with a number of entities in the City who have expressed support for the project and asks for ways in which partnerships with one or more of the supporters would improve the ability of the respondent to meet the City's and the partners' goals.

We believe a publicly owned open access fiber to the premises solution structured with a third party asset manager operating the network is the only solution that fulfils each of LMG's expressed goals. This proposed model suggests LMG as the network owner or a consortium of supporters (that would likely include LMG). Optimally, to secure cooperation and commitment from each key supporter, a consortium ownership model or a consortium backed City ownership model is best.

Freed from operational responsibilities by the asset manager and from customer service responsibilities by the service providers, the owner' primary responsibilities are to set policy and to provide capital.

3.1 Policy

A key problem with broadband delivery throughout the US is that public policy objectives and profit motives seldom align. Policy goals of economic development, quality of life, and equity do not always generate the returns demanded by Wall Street of private sector telecommunications companies. Private sector companies may meet public policy objectives but they will do so only as a means of satisfying revenue and growth demands.

A public owner must achieve revenue goals but does so in order to sustain the network to continue to meet policy objectives. This change in focus, putting policy objectives first, has significant impact on the results broadband development offers a community.

3.2 Capital

Implementing fiber to the premises requires significant capital resources. A municipal owner's access to longer term lower interest municipal bonds can make a significant difference for the project. Backing municipal ownership with a consortium of partners helps protect the City's tax base from potential financial risk.

We propose a capital funding model wherein LMG bonds for capital expenditures backed by payment commitments from a consortium of partners. While some may see this as an unacceptable financial commitment, we believe it is a solution that provides the City the best possible broadband results at the lowest possible risk.

Project performance, PARP support (described beginning on page 90), performance bond support (described beginning on page 89), and a consortium commitment nest the City's financial obligation in a series of protective financial firewalls represented in "Figure 25: Nested Financial Firewalls".

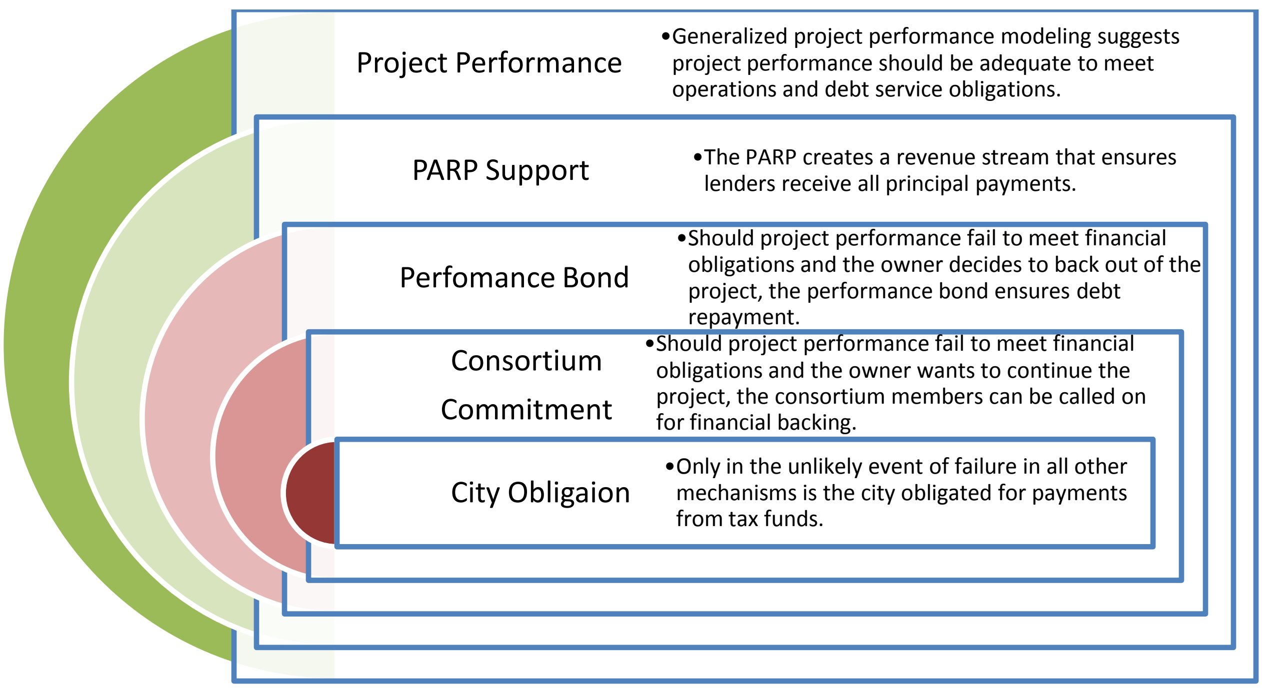


Figure 25: Nested Financial Firewalls

PARP support, performance bond guarantees, and consortium member commitments can be offered directly to the City to support the City's network ownership or the asset manager can be offered as another firewall level. Injecting the asset manager might take the form of a long term lease agreement between the asset manager and the City in which the asset manager agrees to lease the City's broadband assets – transferring operational costs and other risks onto the asset manager. In this type of arrangement, project performance revenues, PARP support, performance bond guarantees, and consortium member commitments would support the asset manager and the asset manager would offer the City a revenue guarantee sufficient to meet debt obligations.

4 Information about the Respondent

Figure 26: O. H. Ivey

OHIvey takes its inspiration from Oscar H. Ivey. During World War II, Mr. Ivey worked in a shipyard installing electronics equipment. At the end of the war, he bought three railroad boxcars of "surplus Army electronics equipment" sight unseen. When he opened the boxcars, he found they contained "modern" telephone equipment. With the help of his Uncle Sam Hearrell, or Uncle Sam, he then purchased a telephone company and converted it from operator assisted dialing to direct dialing. Mr. Ivey was a soldier in the telecommunications revolution of the mid-20th century.

Today, Mr. Ivey's namesake company – OHIvey, LLC – is poised to become the leader in the telecommunications revolution of the 21st century by bringing unique solutions to municipal and other open access organizations deploying state of the art fiber optics to the premises networks in an open access model. The telecommunications future OHIvey sees stems from the growing groundswell of fiber optics to homes and businesses, built with public-private partnerships between municipalities, counties, cooperatives, non-profits and other "public" organizations and private enterprise. Public-private partnership open access fiber to the premises is a disruptive business model poised to reshape the telecommunications industry. Even though public/private partnership fiber to the premises is critical to the future of broadband deployment and services convergence, the model is not in the best interest of legacy network owners, it requires new companies and new thinking to implement.

In order to lead in this market OHIvey has developed the required new thinking and built core competencies around acquiring and managing the resources needed to design, implement, deploy, operate, maintain, market and provide service on open access networks. OHIvey has also entered into a partnership with Mid-State Consultants to add Mid-State's nearly fifty years of industry expertise to OHIvey's revolutionary vision. Together Mid-State and OHIvey have provided feasibility, design, business analysis and other services for networks across the country.

4.1 Values and Purpose

OHIvey is intent on fundamentally changing the way telecommunications is delivered in America. This is a daunting task. When the pressure is on and "our back is against the wall," it is comforting to have clear values and purpose.

4.1.1 Values

OHIvey does everything it does with unfailing devotion to its vision. This requires integrity, fairness, dedication, and competence.

4.1.2 Vision

OHIvey believes in equal access to the 21st Century telecommunications services only true choice on true broadband offer.

4.1.3 Mission

OHIvey creates and supports financially responsible ubiquitously deployed public/private partnership open access fiber to the premises networks.

4.1.4 Statement of Business Purpose

To lead the telecommunications revolution that will bring consumers true choice on true broadband through optical fiber to the premises in an open access network model.

4.2 Mid-State Consultants

OHIvey regularly works with Mid-State Consultants to expand broadband access. Mid-State Consultants, Inc. has been providing a full range of telecommunications analysis, design, engineering, and implementation management services since 1963. Mid-State's staff of over 245 employees includes individuals with years of experience in the industry performing tasks such as strategic planning, business planning, design, OSP (Outside Plant) staking and engineering, ROW (Right- of- Way) acquisition, specifications preparation, contract administration, construction oversight, testing, and all phases of ISP (Inside Plant) design and equipment engineering, selection and testing. Mid-State's team is well-versed in the various technologies available in the communications market, and includes professional engineers licensed in 39 states.

Figure 27: Mid-State Consultants Locations

Mid-State's service offerings range from project inception to final close-out, and troubleshooting to total network management solutions. Mid-State's singular focus has been to provide communications engineering services and support the successful outcome of each project entrusted to us.

4.2.1 Outside Plant Engineering

Mid-State's experienced Outside Plant professionals can help you reach your goals. Providing as much or as little assistance as you require on any project keeps you in control of your project and your expenses.

Whether your outside plant (OSP) infrastructure requires modest upgrades, expansion into new areas, or a complete rebuild, Mid-State Consultants can provide OSP engineering services to get it done right. Their experienced team can be rapidly mobilized to engineer projects of any size, including all right-of-way, permitting and environmental components.

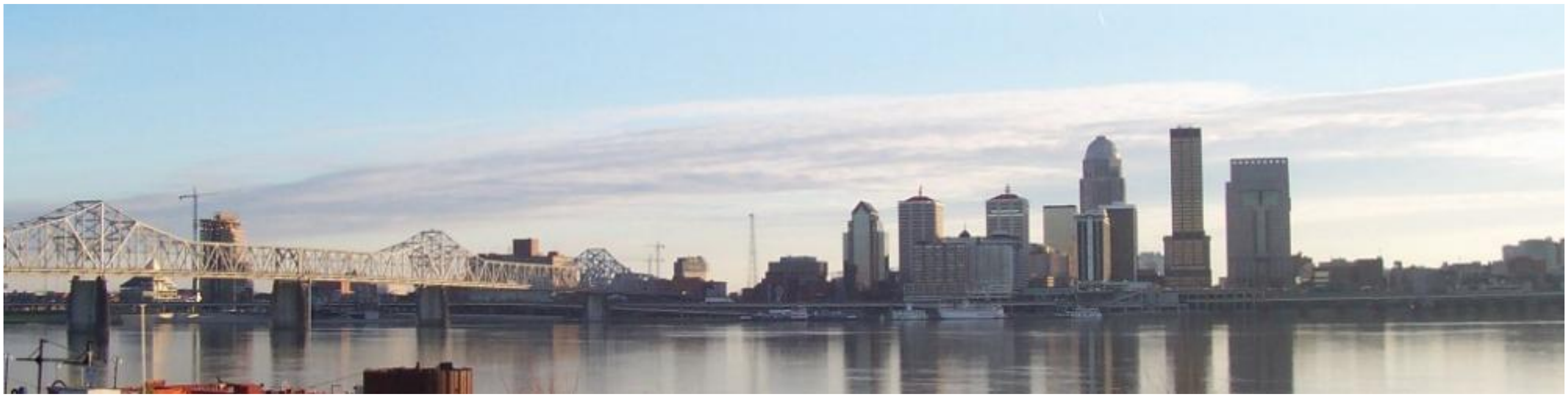
- Staking and Mapping
- Right-Of-Way, Easements, and Permits
- Environmental Studies and Clearances
- Construction Oversight, Inspection, and Testing
- As-Built Documentation

4.2.2 Inside Plant Engineering

The ever-expanding communications landscape provides unprecedented possibilities for voice, video, and data services. The challenge is to leverage existing infrastructure to its fullest and make smart investments in new technologies to satisfy consumer demands. Further emphasizing this is the need to stay ahead of the competition, effectively navigate the ever changing regulatory landscape and migrating toward the ultimate goal of an all IP network. Other possible considerations include integration with wireless services, as well as building and power issues such as lightning protection and emergency generators.

Mid-State will work with you to develop and implement an overall yet flexible plan to meet your immediate network needs and long range goals.

- Switching, Access and Transport for Voice, Video, & Data Traffic
- IP & IT Review and Management
- Equipment Sites



5 Areas of Cooperation

When asking for areas of cooperation, LMG focuses the RFI on resources and facilities, the regulatory environment, contracting issues, and other partnership or revenue opportunities. In the public open access fiber to the premises solution we are suggesting, all of these are important but they begin to work themselves out through the proposed ownership model. The critical factor defining needs in areas of cooperation is the source of capital funding. If the City or partners are willing to provide funding based on the security that can be provided by the tools described in the "Capital Plan" section starting on page 89, then it becomes the interest of the city and partners to develop a cooperative environment to help the project succeed.

5.1 Organizational Structure

The challenge of fiscally responsible ubiquitously deployed public open access fiber to the premises requires a well thought out structure and plan. The plan must include considerations for implementation, network management, and services.

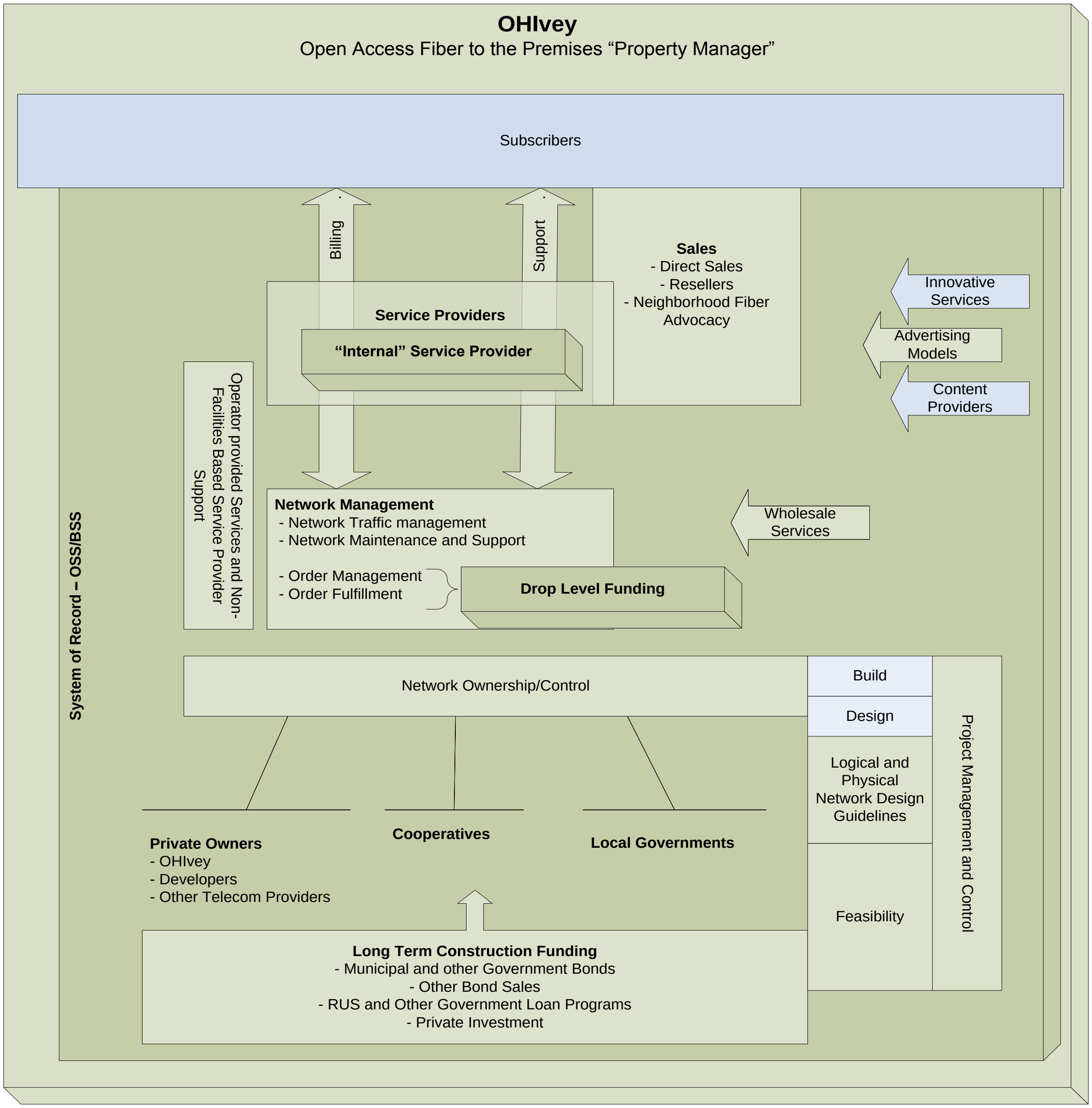


Figure 28: OHIvey Business Framework

"Figure 28: OHIvey Business Framework" depicts the business framework needed to ensure successful deployment and operation of a public open access fiber to the premises network.

Depending on LMG's intent, we can organize a broadband solution for Louisville and the surrounding area with a municipal owner, a broadband authority owner, or a non-profit telecommunications organization owner.

Key players in our proposed solution include:

- **Network Owner** – The network owner is a forward thinking municipality, cooperative or other organization that recognizes the value of true competition on true broadband towards meeting policy objectives. In your network goals, LMG has already demonstrated the vision required of the network owner. As described earlier, in the "Supporters of the Project" section starting on page 80, the network owner can be LMG, a consortium of supporters, or LMG backed by a consortium of supporters.
- **Asset Manger** – The asset manager is a professional services company that manages the operations of the network on behalf of the network owner – freeing the network owner to focus on policy while the asset manager takes care of the day-to-day operations of the network. One method of reducing the risk to the City and opening opportunities for revenue bonds is a relationship where the asset manager leases the facilities from the City. This provides a guaranteed revenue stream for the City to support debt service while retaining control of the vision and public policy support of the network.
- **Service Providers** – Neither the asset manager nor the network owner is a sole provider of retail services on the network. For the network owner to do so could interfere with policy. For the asset manager to do so could lead to a replacement monopoly. Open access networks depend on independent third party service providers offering retail services. To compete with one another multiple service providers must innovate pricing and service solutions that appeal to subscribers.
- **Subscribers** – In an open access environment, subscribers are freed from the shackles of duopoly control and receive the benefits of true competition for their advanced broadband business.

5.2 Capital Plan

Building an open access fiber to the premises network will take about $1,100 per address passed. The project may need other funds to capitalize operational expenses for the first several loss years and to capitalize debt service during this same period. Finally funds may also be required to provide project financial security.

The funding mechanism we most often seek is a municipal revenue bond borrow model protected by a principal protection program and an annuity backed performance guarantee.

OHIvey can occasionally find capital sources. However, public capital sources usually offer lower interest rates and longer terms than private sector sources. This lower interest and longer term enable faster deployment and a more stable project. An annuity backed performance guarantee and a principal protection program increase the total capital requirement but all but eliminate project financial risk – guaranteeing that the lender will be fully repaid without tapping into the City's general fund or drawing on other tax payer supports.

5.2.1 Annuity Backed Performance Guarantee

The annuity backed performance guarantee simply ensures that if the project fails to service the project debt, the insurance provider will rather than the tax payers. The cost of loan default is loss of the project's broadband assets to the insurance provider but the risk of project asset loss offsets the risk of financial loss.

5.2.2 Principal Protection Programs

The concept of a principal protection program is to establish alternate revenue streams to fund principal payments. One such principal protection program is the Live Oak Group's Principal Assumption and Repayment Program.

5.2.2.1 Live Oak Group, LLC

Live Oak Group, LLC is a consulting firm which assists companies in achieving their acquisition of commercial loans. In the current economic environment, both lenders and borrowers have need of loan programs to be available but changes in the lending environment have made that difficult. Live Oak is not a lender, nor does it directly assist in the finding of lenders, but it facilitates the completion of loan transactions.

Live Oak Group, LLC uses Life Settlement Contracts (LSCs), a time proven life insurance product, in a new methodology to bridge the requirement gap between a lender's desire, ability and risk acceptance to fund a credit facility and the borrower's need to qualify for more cost effective large commercial loans. Live Oak offers the commercial lender a virtually risk free structured loan transaction known as the Live Oak Principal Assumption and Repayment Program (PARP). PARP is structured within an irrevocable trust for the protection of all parties.

5.2.2.1.1 Life Settlement Contracts

Since about 1990, the investment community has considered the proposition that there was investment value in Life Insurance policies. It was believed that if a person has excess life insurance, those insurance policies could be sold by the insured at a discount from the face amount. This opportunity might arise, for example, when policies which may have been required by a lender for credit were no longer needed, the policy holder had a need for immediate cash, or some other change in the insured's needs results in current coverage being excessive. The thinking of investors was that if these policies were purchased from the insured and maintained until the death benefit was paid, a better than average return on investment could be realized. As a result, a new industry was born with a new investment product called a Viatical Settlement. Unfortunately, as this type of investment grew in popularity, regulators became aware that unscrupulous investors were abusing the insured, especially the terminally ill (especially in the AIDS community) and the aged. Because of these abuses, the viatical business earned a well deserved bad reputation, was regulated to a standstill, and is illegal in most states.

Legitimate financial institutions and investors, however, still wanted to provide a method by which insured with excess coverage could liquidate their unwanted life insurance policies. Through properly regulated industry controls, the business of legitimately purchasing life insurance policies was renamed to **Life Settlement Contracts** and the participants created a set of rules to govern the industry so that the abuses of the past would not happen in the future. The industry created a very strong, self regulation, training and education association called the Life Insurance Settlement Association[56] to which most reputable businesses in the Life Settlement industry belong and adhere to their business practices guidelines. Some of the major players in the Life Settlement Contract industry are Berkshire Hathaway, Wells Fargo Bank and Credit Suisse.

As indicated, the Life Settlement business has grown in popularity and now includes some of the largest banks, insurance companies and investment firms in the world. The LSCs are structured to make sure the insured has a full and complete understanding of the process. Each LSC is completely documented to maintain the integrity of the instrument and make sure they are investment grade. The documents include complete information on the insured and all heirs, complete medical information including current doctor, acknowledgment from the insurance company of the transfer of ownership and other corresponding documents. Typically, a life settlement contact is a 60 to 70 page package of documents including the policy itself.

5.2.2.1.2 The Principal Assumption and Repayment Program (PARP) Process

The PARP process is not a tool for capital sources to make bad loans or to qualify bad projects. As part of the loan process, each potential borrower's needs are carefully reviewed by the potential lender in the underwriting process to determine suitability of the project and the borrower's position to the loan being considered. The PARP is based upon increasing the loan approximately 50% of the net to the borrower to purchase and maintain the LSCs. Whether the borrower's financial position needs strengthening or not, PARP offers the borrower additional asset value and income to assist in completing and servicing the loan and to the lender, security that the principal will be returned.

As stated, there are significant benefits to both the lender and the borrower using the PARP. The borrower receives the added strength of LSCs to support his fund request and relieve him from the principal repayment. The lender is more protected from exposure to market fluctuations since the principal is protected by PARP and not the borrower. For example, consider the factors listed in "Table 7: Principal Assumption and Repayment Program Example" for a $67,000,000 net to the borrower transaction:

Net Proceeds to the Borrower	$63,500,000
Gross Loan Amount	$100,000,000
Loan Term	13 years
Principal Payments Paid through PARP	Monthly beginning in the 39th month
Interest Rate	6%
Total Interest Paid by Borrower	$50,526,830
Total Fees Paid by Borrower	$12,701,707
Initial Face Value of Life Settlement Contracts	$167,000,000
Trust Average Cash on Hand to Pay Principal	$12,646,239

Table 7: Principal Assumption and Repayment Program Example

[56] See www.thevoiceoftheindustry.com

With the implementation of PARP in structured financing, there is virtually no risk to the lender regarding return of principal. To the lender's benefit, PARP begins making monthly principal payments in the 39th month rather than a single balloon payment at the end of the term, as in typical structured financing programs. Revenue to the lender is higher since the interest is charged on the entire amount going into the trust ($100,000,000) rather than just the amount the borrower would receive ($63,500,000) in traditional funding. Additionally, funds are continuously available from PARP to make the principal payments.

The implementation and operation of PARP works alongside the Lender's normal loan program as described below:

Phase One: Approval and Acceptance

The Lender enhances its loan position by simply adding the Live Oak PARP to its loan procedure as follows:

1. A premium commercial business loan is presented to Live Oak that is at least $63,500,000, for the project. The Borrower must meet underwriting standards when PARP is used, plus the project must be able to support the interest payments and the third party administrator fees. When the Lender has completed its underwriting and has made the decision to move forward, the Lender issues to the borrower and Live Oak a commitment to fund.
2. **Live Oak Loan Accommodation Agreement**: The Borrower executes this document with Live Oak which delineates:
    a. the Borrower's desire to obtain a credit facility from a specific lender
    b. the purpose of the credit facility
    c. the net loan amount required
    d. the additional funds required to secure the PARP
    e. the general terms of the transaction including interest, accommodation fees and administration fees
    f. closing procedures
    g. fee schedule
    h. general transaction terms and conditions.
3. **Trust Agreement**: The Lender, the Borrower, Live Oak (Third Party Administrator), the Trustee (bank or trust company), the Investment Trustee (Live Oak), and the Custodian of the Assets (bank or trust company) execute the ("Name of Borrower") Irrevocable Principal Assumption and Repayment Program Trust. The purpose of this trust is to:
    a. provide for the Custodian of the Assets (bank or trust company) to take into safe keeping the Life Settlement Contracts and pay for them as well as the ability to distribute to the Lender the return of its initial contribution (gross loan amount)
    b. provide funds for use in the Borrower's business
    c. invest funds received from the Lender for principal protection and repayment
    d. establish the holding period (term), timing of distributions, termination and final distribution of the trust
    e. assign the beneficial rights

   f. create an Investment Sub-Trust
   g. establish the general method of business practices for all parties these transactions.
4. **Funding Agreement**: The Borrower, Lender, Live Oak (Administrator) and the Trustee (trust company or bank) execute the Funding Agreement. This document delineates:
   a. the identity of the Borrower, Lender, Trustee and Live Oak as parties to the agreement
   b. that the funding agreement is created pursuant to the Trust Agreement described above
   c. the appointment of an Escrow Agent
   d. the establishment of the parameters for:
      i. pre-closing Funding
      ii. deposits by Lender
      iii. deposits by Borrower
      iv. deposits by Administrator
      v. deposits by Trustee
      vi. actions of Escrow Agent
      vii. release of Escrow Agent
      viii. general operating conditions of the Funding Agreement.
5. Upon the receipt of a letter of commitment by the Lender, Live Oak requests from the LSC provider a detailed list of the pool of life settlement contracts for analysis. Once a reasonable determination that the listed LSCs meet the requirements of Live Oak and the Lender, no less than $160,000,000 in face value of LSCs are placed in safekeeping with a 3rd party life settlement servicing company for vetting. In this way, Live Oak and the Lender can verify for each individual LSC that:
   a. the insurance company is rated no less than “A” by A.M. Best
   b. the insured is between 76 and 84 years old as per Live Oak’s specifications
   c. the ratio of male to female insured policies is as Live Oak specifies
   d. all policies have been in force for at least two years
   e. the premium payments on all policies are current
   f. all policy documentation is complete and verified
   g. the policy pool averages no more than $1,500,000 face value per policy.

Phase Two: Distribution

1. Once the LSC pool is approved, verified and fully vetted, the Lender deposits the gross loan amount with the Escrow Agent.
2. The vetted LSCs are purchased by the Escrow Agent and delivered to the Custodian of the Assets.
3. The Lender is made the beneficiary of the LSCs to be held by the Custodian of the Assets.
4. The Escrow Agent distributes $63,500,000 to the borrower, less any direct fees or expenses designated in the Funding Agreement.
5. The Escrow Agent distributes the funds for broker’s fees and other specific distributions as designated in the funding agreement.
6. The Escrow Agent distributes the balance of the escrowed funds into the Investment Sub-trust for management by the 3rd Party Administrator.

Phase Three: Administration

1. A portion of the funds are assigned to provide for premium payments and to service the LSCs. These designated funds are not available to Live Oak for operations or other purposes until the loan has been paid off or the funds and LSCs deposited are in excess of the outstanding loan balance and there is sufficient cash on hand to secure twelve months premium payments, note payments and service the LSC's for one year.
2. The funds maintained in the Subtrust are supplemented as benefits payments are received from the Life Settlement Contracts. These funds are used as follows:
    a. pay the policy premiums as required by the individual policies
    b. beginning in the 39th month, pay monthly principal payments for the loan based on a 118 month amortization (13 year total term)
    c. purchase additional LSCs as existing LSCs mature to ensure that the minimum face value of the policies held always meets or exceeds the current principal balance.
    d. pay administrative and operational expenses.
3. The administration of the LSCs is subject to an annual independent actuarial audit and verification directed by the 3rd Party Administrator to ensure that the face value of the LSCs always is equal to or greater than the unpaid principal balance.

Phase Four: Final Distribution

Pursuant to the terms agreed to by the Lender, Borrower and Live Oak, after the lender has received 100% of its principal contribution, any remaining funds and/or assets held in the Trust or Sub-trust will be distributed pursuant to the instructions of the 3rd Party Administrator and the trust is terminated.

5.2.3 Capital Plan Summary

Several potential capital plan relationships exist but fundamentally each of them relies on LMG or a regional governmental entity offering access to capital through long term low interest municipal bonds.

6 A Final Note: Lessons Learned

The largest open access fiber to the premises project in the nation is the Utah Telecommunication Open Access, or UTOPIA, network. UTOPIA is a consortium of 16 Utah cities, created to provide construction and operation for a wholesale fiber optic telecommunications infrastructure. Eleven of the cities (Brigham City, Centerville, Layton, Lindon, Midvale, Murray, Orem, Payson, Perry, Tremonton, West Valley) have pledged sales tax revenue to support the bond payments and have some network construction completed. Five cities (Cedar City, Cedar Hills, Riverton, Vineyard, and Washington) are non-pledging and have no network construction complete.

UTOPIA was started network construction in 2004 and has struggled since. When the project was conceived, the intent was to pass 141,000 addresses in three years and to secure over 49,000 subscribers across those addresses. At its three year anniversary, UTOPIA had only completed 26% of its target construction and captured only 12.5% of its target subscribers. Even as late as 2013, UTOPIA had only achieved 46% of its construction goal for 2007 and only 22.7% of subscribers targeted for 2007.

	2003 Goal for Sep. 2007	Actual June 2007	June 2009	June 2011	April 2012	April 2013
Addresses Passed	**141,000**	37,160	48,646	56,000	58,100	65,000
Subscribers	**49,350**	6,161	8,009	8,572	9,340	11,120
Subscription Rate	**35%**	16.6%	16.5%	15.3%	16.1%	17.1%

Table 8: UTOPIA Goals and Results

More to the point, UTOPIA has failed to meet any of its financial goals. “Figure 29: UTOPIA Revenues and Expenses” demonstrates revenues have never kept pace with operating expenses and that debt service has been an additional burden. UTOPIA has had to continue to borrow from its member cities and through its bonding capacity in order to sustain operations and service its debt. As of the end of UTOPIA’s 2013 fiscal year (June 2013) UTOPIA had a negative net asset value of $145,903,223.

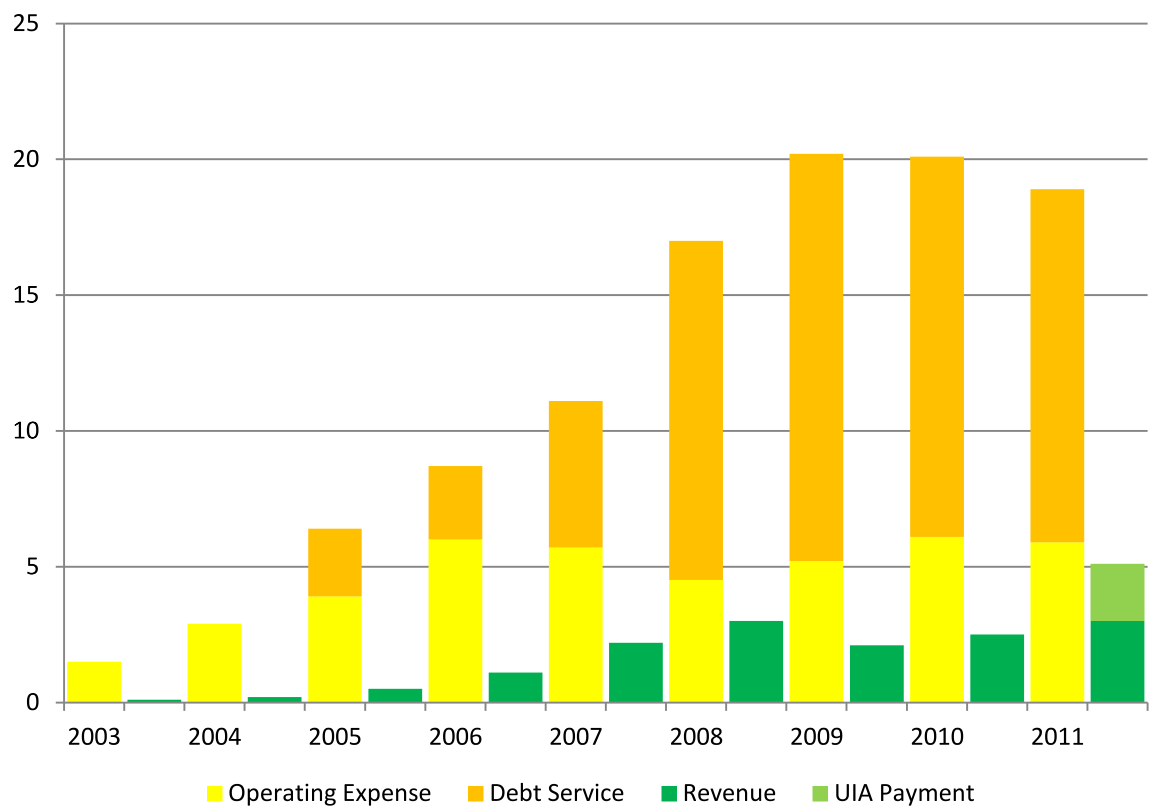


Figure 29: UTOPIA Revenues and Expenses

UTOPIA's sister project, iProvo (in Provo, Utah) also struggled. Maryland State Senator Catherine Pugh recently wrote in the Baltimore Sun opinion section[57], "Taxpayers in Provo, Utah, for instance, spent $40 million to build a relatively small and modest network only to sell it for $1 a few years later because they underestimated the massive costs of operating, upgrading and maintaining it. …[A]s Provo residents learned, even their recently build network – barely a decade old – requires $20 million in upgrades before its new owner – Google – deems it fully operational."

UTOPIA and iProvo serve as warnings for cities considering a municipal broadband project. Quoting again from Senator Pugh's Baltimore Sun op-ed, "For the most part, municipally-built broadband networks have the economic chips stacked against them and, where tried, have saddled local taxpayers with a mountain of debt and half-built networks that are then sold at fire-sale prices to vulture investors." Given such damning evidence, how can we suggest the story will play out differently if Louisville chooses to invest in an open access fiber to the premises network?

[57] Pugh, Catherine (15 August 2013). "The False Promise of Municipal Broadband: Local Governments Keep Building Expensive Networks that Fail to Attract Customers." The Baltimore Sun. http://www.baltimoresun.com/news/opinion/oped/bs-ed-broadband-20130815,0,2185759.story.

We have identified four factors critical to the success of open access fiber to the premises networks: scope, execution, financial planning, and network design.

6.1 Some Lessons Learned

In the discussion in Section "Tipping Points" beginning on page 47, we identified there are relevant variables that help push a project past its tipping point. Experience with multiple municipal projects has demonstrated scope, market execution, financial planning, and network design represent relevant factors at the fulcrum of project success. Of course these are not the only factors that determine the success or failure of the municipal network project. They do, however, represent critical factors. It should also be understood that scope, market execution, financial planning, and network design are inextricably tied together. Nonetheless, we will do our best to address each of them in turn.

6.1.1 Scope

The size, or scope, of a municipal open access fiber to the premises network makes a difference. Scope defines economy of scale opportunities. Scope is a prerequisite to attracting name brand service providers. Scope also enables or restricts network effects.

6.1.1.1 Economies of Scale

There are certain fixed costs when deploying a network of any size. Minimum staff is required to support the network, a head-end must be provided for video services, a network operations center (NOC) must be built, and so on. Most of these core functions require significant initial capital investment and very little incremental investment as new subscribers or addresses passed are added. The greater the scope of the project, the more efficiently it capitalizes on economies of scale.

Both UTOPIA and iProvo have significant excess capacity in their network core and their NOC. At various times, UTOPIA has made arrangements to use the iProvo head-end. The fact that the UTOPIA project could add its demand to the iProvo head-end and the capacity exists to absorb it suggest significant excess capacity.

In order to achieve economy of scale discounts on set top boxes, UTOPIA purchased a very large number of them. When construction failed to pass goal numbers of addresses and take rates were lower than anticipated, UTOPIA was left with significant stock of set top boxes the project could not use and eventually sold them at a significant loss.

6.1.1.1.1 Lessons Learned from UTOPIA and iProvo

Economies of scale are important to maximize fixed cost capital investments and to achieve bulk discounts on equipment and other materials. Nonetheless, it is important to carefully plan and coordinate needs so as not to over purchase to secure bulk purchase discounts.

6.1.1.2 Attracting Service Providers

When SBC acquired AT&T, SBC elected to retain the highly recognizable and trusted AT&T brand. Brand recognition matters to telecommunications consumers. Attracting a recognizable name as a service provider can contribute significantly to the success of a public open access fiber to the premises network. Attracting a recognizable name requires offering a sufficiently large potential market to attract the name brand company's attention.

There is no hard and fast rule defining the scope a project must represent before it can attract name brand service providers. UTOPIA initially indicated it would pass 140,000 addresses and that was sufficient to bring AT&T onto the network as a service provider. However, AT&T first abandoned its triple play intent dropping its video product and later, when it became evident UTOPIA was not going to achieve its 140,000 addresses in three years goal, AT&T abandoned the network altogether. Another name brand service provider indicated that if the project were larger than 180,000 addresses they might be interested in participating.

A name brand service provider offers a municipal project three critical benefits:

- First, many consumers purchase telecommunications services based on brand recognition. Providing consumers with a name they know and trust will increase take rates.
- Second, a name brand service provider's decision to participate on the network represents a vote of confidence in the project from the service provider. That vote of confidence can be useful when persuading businesses and residents to subscribe to the network.
- Finally, a name brand service provider is more likely to have the resources to innovate on the fiber network than smaller providers. Innovative applications that truly differentiate the fiber network from the incumbent copper networks is very valuable to the network and magnifies the value of network effects.

iProvo was initially only able to attract little known and now defunct HomeNet as a service provider. HomeNet failed at about the time AT&T abandoned its UTOPIA triple play intentions. This left both projects scrambling to find a triple play provider. MStar, a largely specialized DSL reseller, indicated they could develop triple play services and became the primary service provider on both networks until that company's failure. Thus, both projects started with a little known service provider as the anchor tenant. UTOPIA had AT&T on the network for over a year but AT&T maintained a "wait and see" posture, did not use its name brand to advance UTOPIA's success, and eventually abandoned the project.

6.1.1.2.1 Lessons Learned from UTOPIA and iProvo

Neither iProvo nor UTOPIA achieved the scope required to attract and retain a nationally known name brand service provider. This failure may have contributed to the soft take rates experienced by both projects.

6.1.1.3 Network Effects

We have discussed Network effects starting on page 45. Sufficient scope fuels network effects. Insufficient scope strangles continuing growth.

6.1.1.3.1 Lessons Learned from UTOPIA and iProvo

As of 2013, UTOPIA had passed 65,000 addresses with limited construction continuing in 2014 and beyond. Recently UTOPIA announced a potential partnership with Macquarie Capital with the understanding that scope makes a significant difference[58]. iProvo passed 35,000 addresses and has reached the limits of its growth. Neither of the projects on their own – or even combined – represent a sufficient market size to inspire development of new fiber dependent network effect applications.

To truly succeed, markets for fiber projects around the nation need to aggregate their markets for application developers. Louisville should not only build its more than 130,000 addresses but the project should expand into the Jefferson County and look for other ways to expand its potential market size as well as put in place support structures that help application developers tie into the markets in Kansas City, UTOPIA, iProvo, Chattanooga, and other very high speed networks.

6.1.2 Execution

We have already discussed that market surveys typically predict between 40% and 80% take rates for fiber overbuild projects.

Residential				Business/Commercial
100% of Very Likely & Somewhat Likely	76%	Potential Market	79%	100% of Very Likely & Somewhat Likely
100% of Very Likely plus 50 to 70% of Somewhat Likely	59% to 66%	Likely Market	61% to 68%	100% of Very Likely plus 50 to 70% of Somewhat Likely
100% of Very Likely	42%	Minimum Market	43%	100% of Very Likely

Table 9: Composite Market Survey Results

Yet many municipal projects struggle to achieve these projected take rates. "Figure 30: UTOPIA Take Rates through Time" shows the UTOPIA project has languished at between 15% and 17% take rates for more than four years.

[58] See Pugmire, Genelle (20 December 2013). "UTOPIA Announces Partnership with Private Capital Company". Daily Herald. Viewed 21 January 2014 at http://www.heraldextra.com/news/local/central/orem/utopia-announces-partnership-with-private-capital-company/article_e364dbb4-6901-11e3-ad10-0019bb2963f4.html.

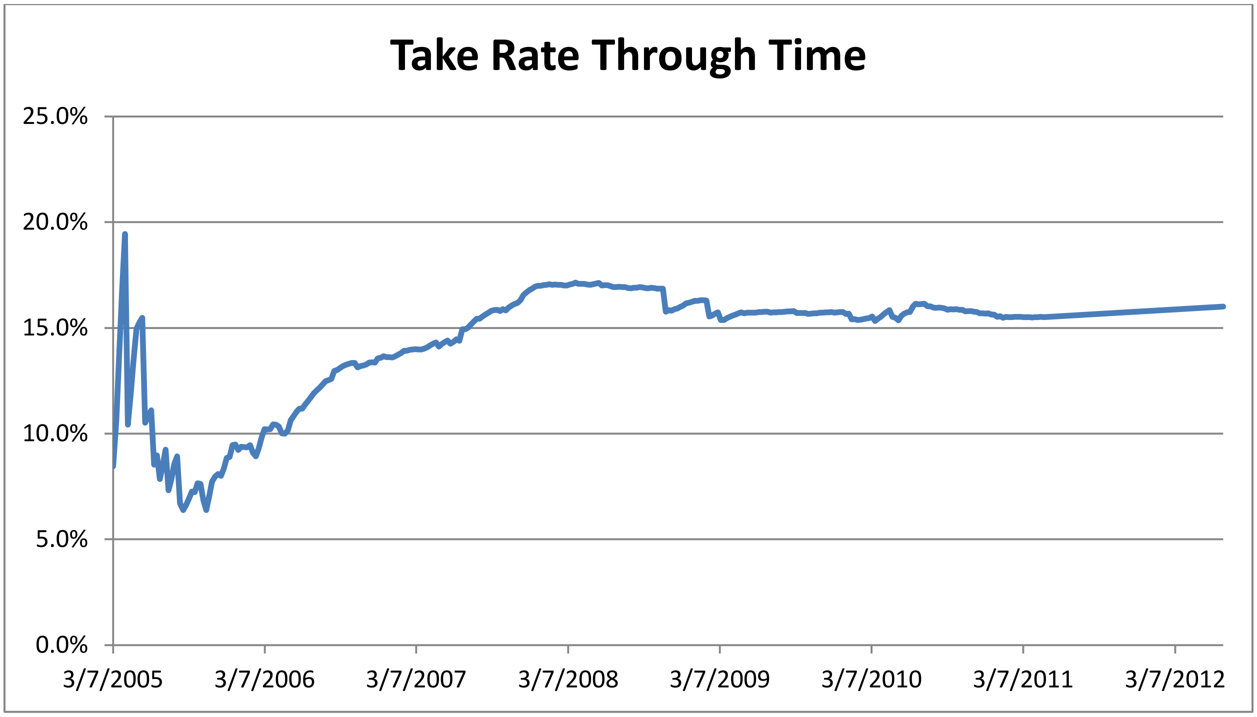


Figure 30: UTOPIA Take Rates through Time

The iProvo project has experienced very similar results to that of UTOPIA.

Unfortunately, as depicted in "Figure 31: Fiber Project Monthly Revenue and Expense" generic feasibility modeling suggests a fiber to the premises project needs to reach about a 30% take rate to meet financial obligations.

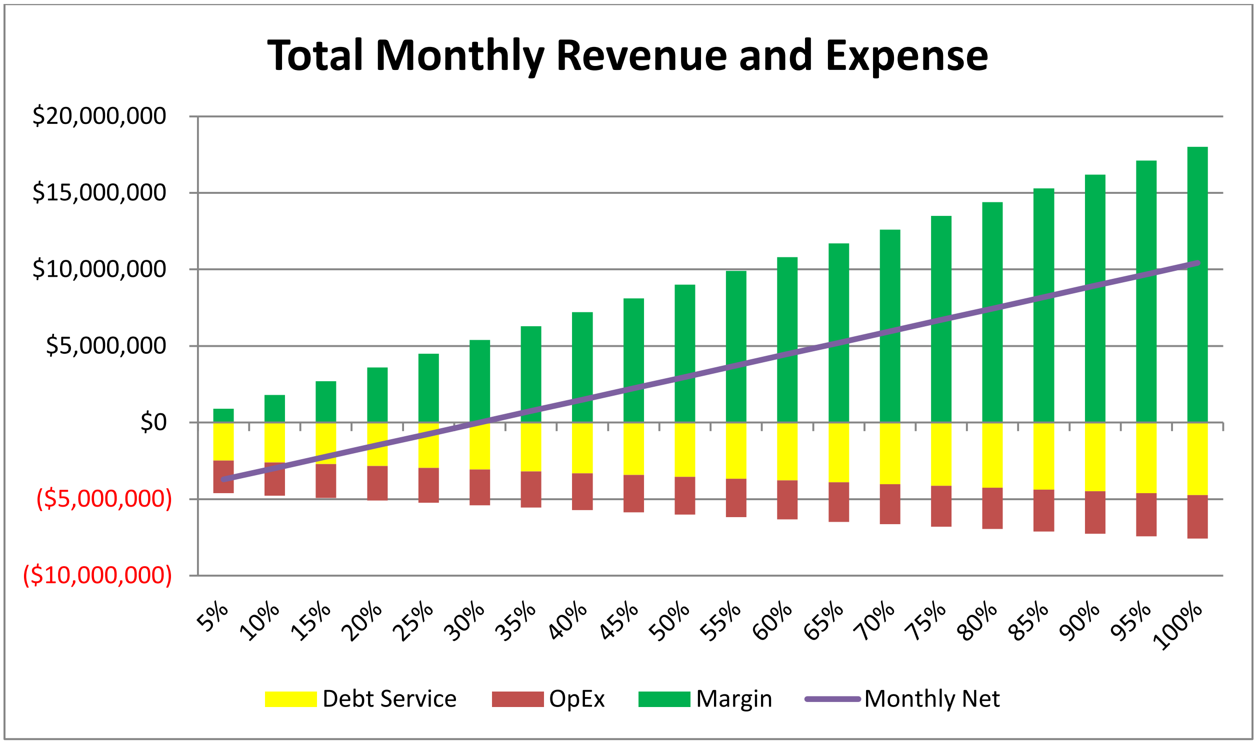


Figure 31: Fiber Project Monthly Revenue and Expense

The question must be asked, "What about these projects' market execution keeps them from passing take rate thresholds required to make them successful?"

In 2003, UTOPIA contracted Dean & Company to conduct a feasibility study. Dean & Company concluded with three recommendations to create a strategic focus on several factors that are key to maximizing the economic value created by the project. These recommendations included:

- Capitalize fully on perceived Local/Community advantage in marketing UTOPIA-based services
- Recruit providers of unique FTTH-intensive applications to differentiate UTOPIA from Comcast and Qwest broadband capabilities, e.g. telecommuting, entertainment-on-demand, gaming, home networking . . .
- Strong focus on serving the business community to capture the productivity benefits of fiber broadband. UTOPIA's sponsors should develop an integrated economic development plan around the benefits of a fiber infrastructure

As discussed above in the "Diffusion Theory" section (page 41), in a 2002 feasibility study conducted by the Strategic Research Institute (SRI), SRI provided a discussion on the diffusion theory and identified what Geoffrey Moore calls the "chasm theory" in the diffusion theory of new innovations. The Dean & Company recommendation could have helped the UTOPIA project (and iProvo, for that matter) overcome soft take rates and cross the chasm. Before we look at the Dean & Company recommendations in more detail, let's review Moore's "chasm theory" in diffusion theory.

Without executing specific efforts to overcome the pragmatist inclination not to buy, the municipal project should expect take rates that include innovators and early adopters – or about 17% of the available market.

6.1.2.1.1 Lessons Learned from UTOPIA and iProvo

Neither iProvo nor UTOPIA created marketing efforts that would encourage early adopters to share positive experiences and recommend the network to the early majority. In fact, UTOPIA was greatly hampered by the fact that service availability has languished in a quilt like pattern due to lack of capital funds. This quilt like availability makes it so that even if an early adopter makes a recommendation, the potential subscriber may not be able to get service. The dampening effect of this quilt like availability on take rates is dramatically represented in a comparison between two UTOPIA cities: Payson and Lindon. In both Payson in Lindon, some construction was finished in Phase I of the UTOPIA project 2004-2005. Both projects then languished until 2007 at which time Lindon was largely completed and Payson was not.

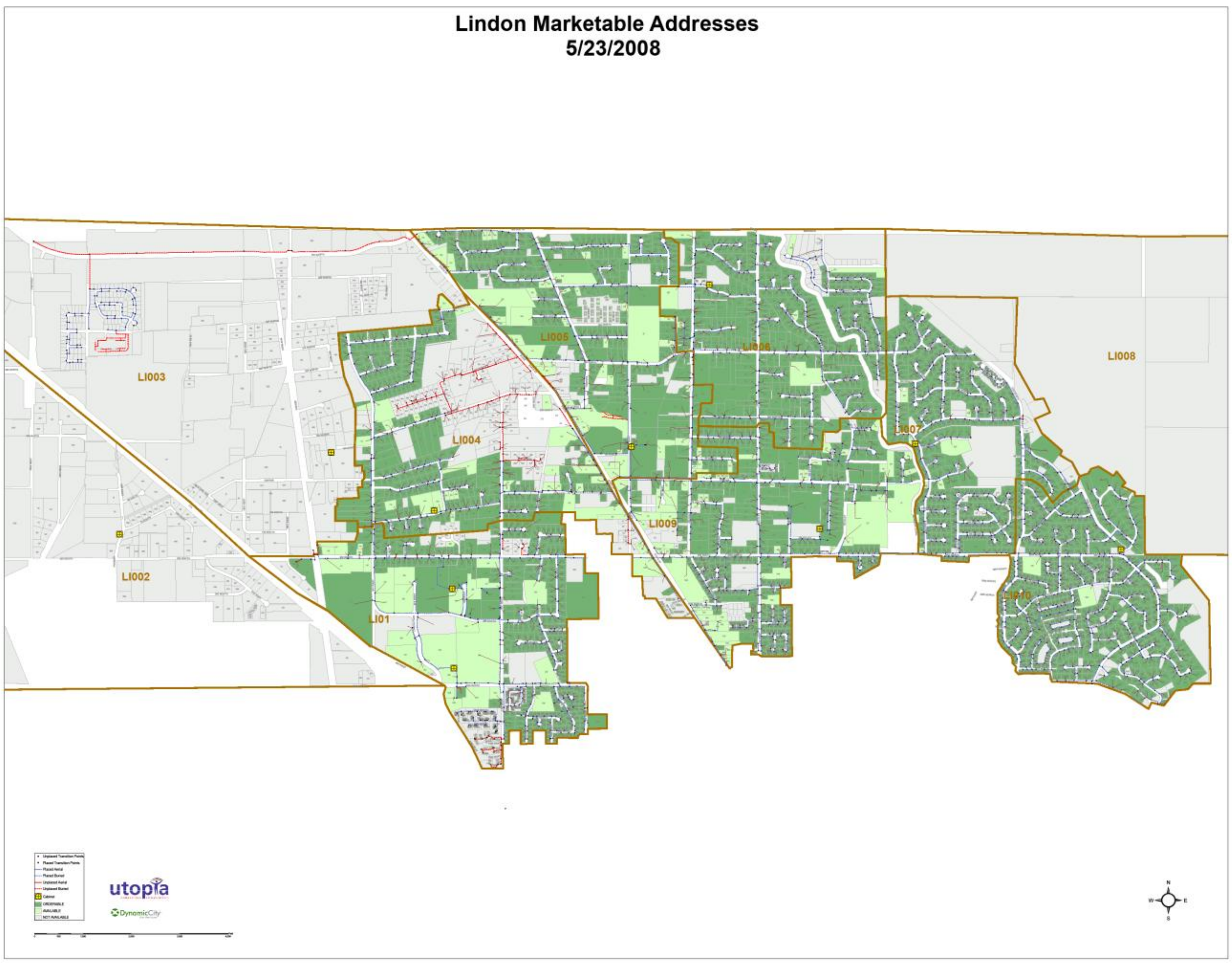


Figure 32: Lindon Available Addresses (in green)

"Figure 32: Lindon Available Addresses (in green)" shows available addresses in Lindon after 2007 construction was complete. The unavailable areas (in gray to the west and east of the bulk of the town) are largely undeveloped.

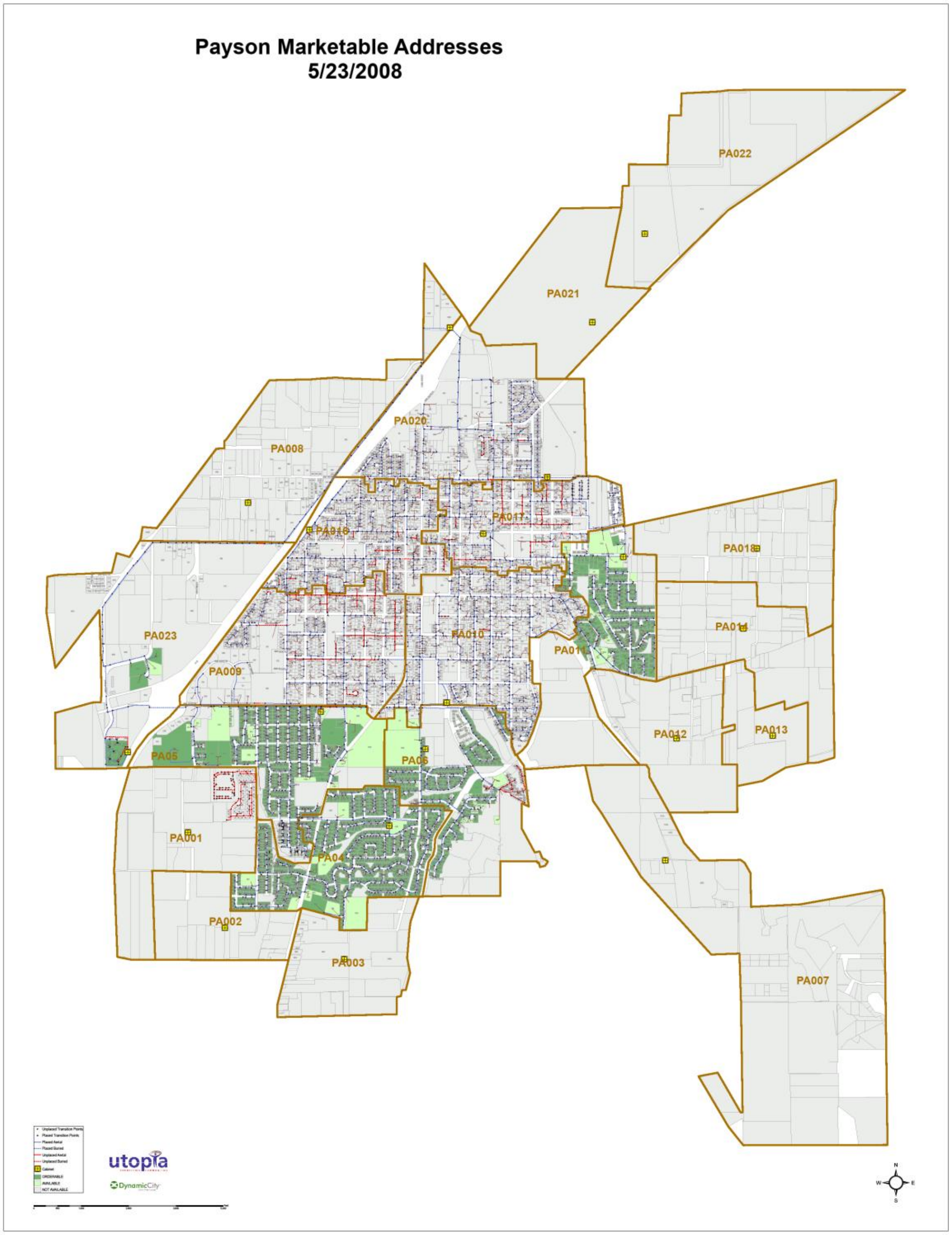


Figure 33: Payson Available Addresses (in green)

"Figure 33: Payson Available Addresses (in green)" shows available addresses in Payson after Phase II construction (2007). While much of the outlying areas of Payson are undeveloped, the unavailable area in the center of the map represents the majority of addresses in Payson.

So, what was the take rate impact of availability and the power of word of mouth marketing as early adopters make recommendations to other potential customers?

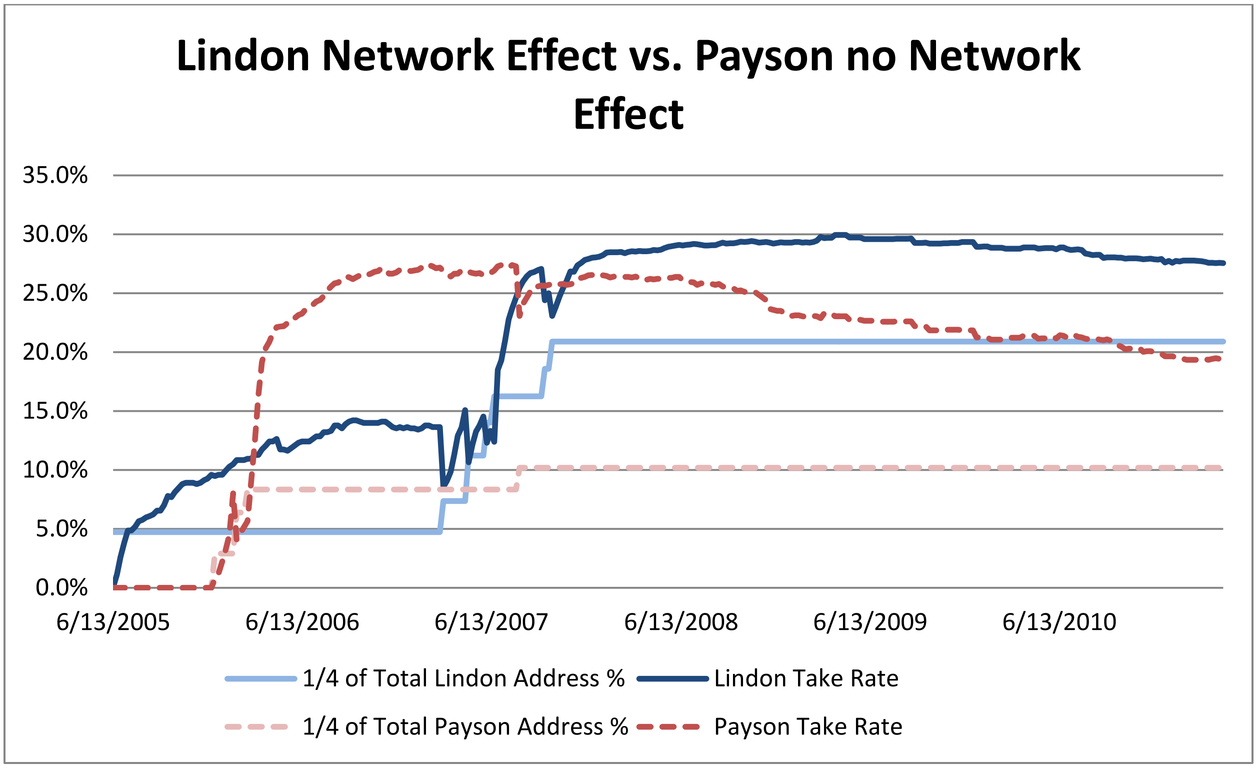


Figure 34: Lindon vs. Payson Take Rates

"Figure 34: Lindon vs. Payson Take Rates" shows Lindon experienced a significant increase in take rate (that is percentage of subscribers versus available homes) after the 2007 Phase II construction and Payson did not.

Of course some of the boost may have been from network effects or other factors. Nonetheless, the lesson learned is to ensure mechanisms are in place to close the diffusion chasm between the early adopters and the early majority to get beyond 17% take rates.

6.1.2.2 Community Benefits

A municipal fiber to the premises network can provide community benefit without the stigma of generating profits for a behemoth out of town provider. These benefits can include economic development, education opportunities, health care advantages, civic engagement opportunities and others. All of the potential benefits of a municipal fiber network exist to one extent or another in the iProvo and UTOPIA networks. However, neither community has done an effective job of highlighting them. A quick search for either project will reveal a long list of articles about them – most of them dealing with the projects' financial struggles and the projects' teams' responses to criticisms about their financial struggles.

The interlocal agreement that chartered UTOPIA states, "WHEREAS, this joint effort in creating a wholesale telecommunication utility makes the most efficient use of the Members' powers in a mutually advantageous way, including the benefit of economy of scale, which will facilitate superior services to residences and businesses; enhance government administration; provide more functional buildings and grounds; support better educational opportunities, health care, and police and fire protection; and spur economic development." This chartering statement indicates the network will:

- Facilitate superior services to residences and businesses,
- Enhance government administration,
- Provide more functional buildings and grounds,
- Support better educational opportunity, health care, and police and fire protection, and
- Spur economic development

However, when we look at UTOPIA's web site (http://www.utopianet.org), we can learn about residential and business services but we cannot find anything celebrating how the project meets the other chartering objectives. It is almost as if UTOPIA has abdicated its chartered responsibility and abandoned the community benefits message Dean & Company suggested the project focus on.

6.1.2.2.1 Lessons Learned from UTOPIA and iProvo

Community benefits are an important reason municipalities undertake to build broadband networks. If the network operators fail to highlight the community benefits, they are reduced to competing with incumbent providers on the incumbent provider's terms.

In both the iProvo and UTOPIA projects, early project leaders focused on the financial benefits the projects would bring the cities. Project leaders suggested the networks would become not only self sufficient enterprise funds but that they would generate profits that could be used for other community enhancing projects. When the projects failed to produce the revenues to do so, the perceived community benefit was also lost. Baltimore should focus on the community benefits intrinsic in the community network, not those that can come as a secondary benefit as revenues are (or are not) generated from the network.

6.1.2.3 Differentiation

Dean & Company recommended to UTOPIA that the project "recruit providers of unique FTTH-intensive applications to differentiate UTOPIA from Comcast and Qwest [now CenturyLink] broadband capabilities…". The same advice could easily have gone to the iProvo project. Doing so would have created a reason to subscribe to the fiber network over the incumbents and would have helped create a virtuous cycle of network effects.

Unfortunately, neither network was able to recruit providers willing to offer fiber intensive applications. In point of fact, both networks restricted their ability to do so by providing wholesale packages that encouraged service providers to offer services very similar to the incumbents. Rather than creating the environment of bandwidth abundance and application innovation that a fiber network should offer, UTOPA's and iProvo's wholesale packages encouraged marketing bandwidth scarcity and forced service providers to think of services in traditional triple play silos.

6.1.2.3.1 Lessons Learned from UTOPIA and iProvo

A fiber to the premises network is significantly different than a traditional copper based network. Municipal fiber projects must emphasize bandwidth abundance and innovative application delivery.

If the municipal project is not able to recruit innovative application providers, the project may have to develop innovative services it makes available to its service providers on a wholesale basis.

6.1.2.4 Business Community

The Dean & Company feasibility report suggested a "Strong focus on serving the business community to capture the productivity benefits of fiber broadband." Both UTOPIA and iProvo indicated they were focusing on businesses but their practices demonstrated otherwise.

First, UTOPIA and iProvo chose pricing models that charged businesses extra for services not because the services were different but rather simply because the subscriber was a business. This pricing model is a legacy arbitrage model from the days when incumbent providers were forced to compensate for regulated thin margin residential price caps by charging businesses premiums. While the industry accepts the practice, it does not represent a strong focus on serving the business community.

Next, UTOPIA and iProvo chose to handle business order fulfillment differently than residential order fulfillment. In both projects cases, the business order fulfillment timeline was (and is) significantly longer than the residential order fulfillment timeline.

Finally, neither UTOPIA nor iProvo established relationships with business service integrators or built any kind of effective business channel partnering.

In sum, saying you have a focus on businesses does not mean that you do.

6.1.2.4.1 Lessons Learned from UTOPIA and iProvo

The residential marketplace represents the vast majority of potential subscribers for a ubiquitous fiber to the premises deployment. Some fiber over builders (like Google) have elected to focus almost exclusively on the residential marketplace. However, a true focus on businesses can help spur revenues and accelerate take rates for both business and residential subscribers. The focus has to be substantial and more than simply words.

6.1.3 Financial Planning

Both UTOPIA and iProvo made three critical financial planning mistakes:

1. Neither project included sufficient capital for customer connections.
2. Neither project established financial backstops, guarantees, or insurance mechanisms.
3. Both projects advertised early that they would not only be self sufficient but would also generate revenue for their participating cities.

UTOPIA further exacerbated its financial distress by not having sufficient funding secured to finish the project at the project's outset.

6.1.3.1 Include Sufficient Capital for Customer Connections

Both UTOPIA and iProvo deferred drop level infrastructure costs to the order fulfillment process. Because of this, financial analysts for both projects considered drop level infrastructure costs an operational cost, not a capital cost. Averaged through time, drop level infrastructure has little impact on operations. However, in the initial weeks and months after a service area becomes available, new connections consume significant resources. This imbalance can tip the project into failure – especially if there is no source of funds for customer drops.

6.1.3.2 Establish Financial Backstops

UTOPIA and iProvo are frequently used by opponents of municipal projects as case studies of why cities should not get engaged in broadband projects. The argument goes that municipal projects are financial drains on the cities who try them because municipal broadband represents a group of broadband amateurs entering a very competitive marketplace. Returning to Senator Pugh's op-ed, "Those who want to win the argument about whether government can stimulate a struggling economy would be well advised to stick with what we know works and stay away from fanciful boondoggles."[59]

There is certainly financial risk involved in building a municipal broadband network. However, we believe we have found mechanisms to guarantee against that risk. We propose using a life settlement investment vehicle to create a principal assumption and repayment program – thus removing principal repayment from the project's debt service model. We further propose using an annuity based performance bond to guarantee project success.

Of course these insurance policies come at a cost. To create a near zero financial risk project, we would nearly double the capital outlay required at the outset of the project. However, the financial backstops are designed to protect the capital required to build the network as well as the capital required to protect the investment.

In sum, we suggest that we can build an open access fiber to the premises network for the City of Baltimore at near zero risk to the City itself.

6.1.3.3 Do Not Focus Conversation on Excess Positive Revenue

Municipal networks have many community benefits. One of them might be generating positive cash flow that can be transferred to other community development projects. Unfortunately, UTOPIA and iProvo emphasized positive cash flow as a key benefit of the projects. When positive cash flow failed to materialize, opponents of the projects had an easy time arguing the projects were failures.

[59] Pugh, Catherine (15 August 2013). "The False Promise of Municipal Broadband: Local Governments Keep Building Expensive Networks that Fail to Attract Customers." The Baltimore Sun. http://www.baltimoresun.com/news/opinion/oped/bs-ed-broadband-20130815,0,2185759.story.

6.1.3.4 Secure Sufficient Funding to Finish the Project

The UTOPIA project originally envisioned three phases of construction. Because of restrictions in Utah law, the project was only able to use tax backed bonds for the first phase of the project. The intent was that revenues from the first phase would be sufficient to justify revenue bonds for additional construction. When revenues were insufficient to justify revenue bonds, UTOPIA had no backup plan and was left with a partially completed quilt like footprint of available addresses.

6.1.4 Network Design

UTOPIA and iProvo both had good network designs similar to those outlined in this report. Unfortunately, good network design could not compensate for failures of scope, in execution, and in financial planning.

6.2 Some Failing Strategies

The UTOPIA, iProvo, and other municipal experiences also demonstrates some failing strategies.

6.2.1 Arbitrage Pricing in a Non-Arbitrage Environment

As a regulated monopoly AT&T had a state public utilities commission requirement to provide affordable universal residential telephone service. This regulation forced the local operating companies to offer residential service near or, sometimes, below the cost of offering that service. In order to afford the cost of doing so, “add-on” services like second lines, call forwarding, and other features were priced to produce significant profit. As businesses were not included in the universal service requirement, the operating companies also established significant cost variation based not on the type of service being provided but rather on the type of customer subscribing to the service.

In Digital Crossroads: American Telecommunications Policy in the internet Age Jonathan Nuechterlein and Philip Weiser write:

> *All these implicit subsidies – geographic cost averaging, above-cost business rates, above-cost access charges, above-cost second lines, among others – are politically convenient. They are all economically equivalent to a special tax imposed on some customers or services. And, precisely because they are “implicit” rather than “explicit,” they come without the political baggage of an explicit tax or universal service fee.*
>
> *But these are “taxes” with a special drawback: customers can avoid paying them altogether if they can find a provider other than the regulated local telephone company to perform the same services at a lower price – i.e., without the implicit tax inherentin the regulated rate. New entrants in any market know this, and they will make it their first priority to cherry-pick the very customers who are paying the largest implicit taxes. This cherry-picking is a form of arbitrage – a low-risk profit opportunity arising from arbitrary distinctions. The new entrants that exploit such opportunities inexorably undermine the whole scheme of implicit cross-subsidies, but they are doing nothing*

> *wrong. They are merely delivering the message that this traditional scheme, designed for monopoly market conditions, is unsustainable in a competitive era*[60].

One of the objectives of the 1982 consent decree ending the antitrust case of US vs. AT&T was to end these instances of implicit taxation. In the consent decree Judge Harold Greene wrote, "The charges for each type of exchange access shall be cost justified and any differences in charges to carriers shall be cost justified on the basis of differences in services provided."[61]

Even though the consent decree mandated that charges between carriers be cost justified on the basis of differences in services, the mandate did not translate onto retail pricing. Carriers, taking advantage of the markets demonstrated price tolerance, continued to charge above-cost rates for historically above-cost services. Only now, there was no implicit taxation, no cross-subsidization. Even after the Universal Service Fund was established in 1997 to meet the objective of ubiquity, above-cost retail rates continued.

Competition has served to erode some of the margins in above-cost services but most competitors continue to price services as high as the market will bear leaving in place a dichotomy of high profit "business services" and low profit "residential services" which, often times, are similar in every way except the subscriber class.

This arbitrage pricing in an non-arbitrage environment is not only unsustainable but it is also counter-productive to many of the policy goals public entities pursue when they enter into a telecommunications project.

6.2.2 Myopic Operational Focus and Pinballing

Many have taken the fragment from the Greek poet Archilochus which translates, "The fox knows many things, but the hedgehog knows one big thing," to generally bisect world views. On the one hand are the hedgehogs who identify a central precept and then relate everything to that one idea. On the other hand are the foxes who see their environment as a complex set of variables that may or may not be related to any particular central idea.

There are great advantages to tackling a public open access fiber to the premises project from the perspective of a hedgehog. The core values for which the project stands should be identified early. Objectives should be established to support those values and measures put in place to evaluate progress towards meeting those objectives.

The danger lies when the hedgehog perspective is allowed to trickle down from the project's values and into its operational focus. That is, when, for example, the project suggests that greenfield development or business services are the key to success and the public project is managed to meet only greenfield or

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[60] Nuechterlein, Jonathan E. and Philip J. Weiser (4 February 2005). Digital Crossroads: American Telecommunications Policy in the Internet Age. MIT Press; Cambridge, MA. P. 54-56

[61] US District Court for the District of Columbia (24 Aug 1982). "United States of America, Plaintiff, v. Western Electric Company, Incorporated, and American Telephone and Telegraph Company, Defended: Civil Action No. 82-0192. Modification of Final Judgment." US District Court for the District of Columbia. Appendix B p. 4.

business subscriber needs. When greenfield or subscriber revenues do not meet project needs management often pinballs to another “saving” business sector.

When fox thinking is allowed to permeate the project’s public policy objectives, the project will lose sight of its public purpose and risks functioning as nothing more than another inadequate telecommunications provider using public subsidies to compete in a historically private marketplace. Avoiding this risk depends heavily on project governing bodies retaining an unrelenting focus on the project’s core values and policy objectives.

On the other hand, if hedgehog thinking is allowed to drive operational decisions, the project runs the risk of turning from one inadequate silver bullet solution to another. One quarter greenfield implementation will be the salvation of the project – until the housing market softens and new housing starts decline. The next quarter business services will solve all of the project’s woes – until competition drives too much margin out of above-cost business service pricing. Avoiding this risk of hedgehog thinking in operations depends heavily on project operational staff retaining fox-like thinking to take advantage of every possible avenue to success available to them.

7 Appendixes

7.1 Terms and Acronyms

2G: In the world of cell phones, 2G signifies second-generation wireless digital technology. Fully digital 2G networks replaced analog 1G, which originated in the 1980s.
2G networks saw their first commercial light of day on the GSM standard. GSM stands for global system for mobile communications.

3G: Third generation of the mobile telephony standard. Analog cellular was the first generation and digital PCS the second.

4G: Abbreviation for fourth-generation wireless. Specifies a mobile broadband standard offering both mobility and very high bandwidth. Usually refers to LTE and WiMax technology.

Access Level Infrastructure: Infrastructure required to deliver services from the community cabinet or hub to the customer access point. Access level infrastructure ties to distribution rings at the community cabinet and to drop level infrastructure at the customer premises. Access level infrastructure is typically part of the local loop.

Access Portal (AP): The transceiver or media converter device that terminates a fiber network at the customer's premises. Other names for the AP include Optical Network Termination (ONT) or Ethernet Demarcation Device (EDD).

ADSL: See Asymmetric Digital Subscriber Line.

Aerial: Infrastructure placed in above ground installations.

Aggregation: See Demand Aggregation.

Aggregation Point: Aggregation point is used to describe a) a location where multiple fiber runs come together or b) a network location where multiple sites aggregate traffic.

Analog: Relating to or using signals or information represented by a continuously variable physical quality such as spatial position or voltage.

Analog Reclamation: In a cable system, refers to repurposing spectrum previously used to carry analog channels for other uses for digital channels or high-speed data.

AP: See Access Portal.

ARPU: See Average Revenue Per User.

Asymmetric Digital Subscriber Line (ADSL): A technology that transmits a data signal over twisted-pair copper, often over facilities deployed originally to provide voice telephony. Download rates are higher than upload rates - i.e., are asymmetric. ADSL technology enables data transmission over existing copper wiring at data rates several hundred times faster than analog modems using an ANSI standard.

Name	Download	Upload
ADSL	8.0 Mbps	1.0 Mbps
ADSL (G.DMT)	12.0 Mbps	1.3 Mbps
ADSL over POTS	12.0 Mbps	1.3 Mbps
ADSL over ISDN	12.0 Mbps	1.8 Mbps
ADSL Lite (G.Lite)	1.5 Mbps	0.5 Mbps
ADSL2	12.0 Mbps	3.5 Mbps
RE-ADSL2	5.0 Mbps	0.8 Mbps
Splitterless ADSL2	1.5 Mbps	0.5 Mbps
ADSL2+	20.0 Mbps	1.1 Mbps
ADSL2+M	24.0 Mbps	3.3 Mbps

Asymmetrical: Internet connections have two components - a downstream and upstream. When the two speeds are not comparable, the connection is termed asymmetric. Typically, phone and cable companies offer much slower upload speeds than download, in part because the Internet tended to be a download-centric system in the 90's and early 00's. However, users increasingly need faster upload connections to take full advantage of modern applications.

Asynchronous Transfer Mode (ATM): A means of digital communications that is capable of very high speeds; suitable for transmission of images or voice or video as well as data; ATM is used for both LAN and WAN.

AT&T U-Verse: An AT&T brand of triple-play telecommunications services delivered via fiber to the node.

ATM: See Asynchronous Transfer Mode.

Availability Gap: See Broadband Availability Gap or Investment Gap

Average Revenue Per User (ARPU): "Average revenue per user is calculated by dividing revenues by the subscriber base. Non-service revenues, such as equipment or other sales, are included in the calculation." From http://www.yourdictionary.com/finance/arpu.

While the accurate calculation of ARPU requires inclusion of non-service revenues, many organizations exclude them when calculating ARPU .

Backhaul: A general term for the segment of a network connecting the network to an Internet peering point.

Bandwidth: The rate at which the network can transmit information across it. Generally, higher bandwidth is desirable. The amount of bandwidth to you can determine whether you download a photo in two seconds or two minutes.

Bit: The base unit of information in computing. For our purposes, also the base unit of measuring network speeds. 1 bit is a single piece of information – a one or zero, on or off, true or false. Network speeds tend to be measured by bits per second – using kilo (1,000), mega (1,000,000), and giga (1,000,000,000). A bit is a part of a byte – they are not synonyms. Bits are generally abbreviated with a lower case b (as in M<u>b</u>ps). Bits are used to measure network speeds. Bytes (abbreviated with an upper case B – as in M<u>B</u>) are used to measure storage space and file sizes.

That smash hit two hour long high definition movie you want to download is probably 8+ G<u>B</u>. If you want to download it on a standard DSL line, you better have about six hours (8 billion bytes * 8 bits = 64 billion bits / 3 million bits per second = 5.9 hours).

BPON: See Broadband Passive Optical Network.

Broadband: According to the FCC, 4 Mbps download and 1 Mbps upload. True broadband provides exponentially faster speeds and is often symmetrical.

Broadband Availability Gap: Either a) The amount of funding necessary to upgrade or extend existing infrastructure up to the level necessary to support the National Broadband Availability Target. Because this is a financial metric it is referred to as the Investment Gap. Or b) the difference in bandwidth and services available between two geographic areas, socio-economic strata, age generation, ethnic groups, or other groups.

Broadband Friendly: Policies designed to lower the costs and risks of deploying broadband in a community.

Broadband Passive Optical Network (BPON): A type of PON offering downstream capacities of up to 622 Mbps and upstream capacities of up to 155 Mbps shared among a limited number of end users.

Broadband Technology Opportunities Program (BTOP): The Department of Commerce broadband funding program.

Brownfield: Brownfield neighborhoods are neighborhoods that are already build out and typically have existing roads, sidewalks, landscaping, and other impediments to network deployment. Brownfield neighborhoods typically have existing networks requiring new entrants to overbuild unless the incumbent is required to unbundle.

BTOP: See Broadband Technology Opportunities Program.

Burst Rate: The maximum rate or "speed" which a network is capable of delivering within a short timeframe – typically seconds or minutes. This is usually expressed as a rate in Mbps. Many network providers report their burst rate as their maximum advertised speed.

Byte: The base unit for file storage comprised of 8 bits. A 1 MB (megabyte) file is made of 8 million bits. Bytes generally refer to the size of storage whereas bits are used to discuss how rapidly files may be moved.

Cable Modem System: Cable television companies have offered Internet access via their cable systems since 1997. The network architecture uses a loop that connects each subscriber in a given neighborhood, meaning they all share one cable to the Internet. Because the cable network shares the last mile connection among potentially hundreds of subscribers, a few bandwidth hogs can slow everyone's experience.

Cable Television (CaTV): In its original incarnation the acronym was CATV standing for Community Antenna or Community Access Television. The CaTV acronym stands for Cable Television. In either case, cable television uses coaxial cable to deliver video signals from a single receiver to multiple homes. Cable television technologies almost always "broadcast" all available channels on the cable and rely on in home tuners to select a channel from the broadcast stream.

CAF: See Connect America Fund.

CAI: See Community Anchor Institution.

CAP: See Customer Access Point.

Capacity: Ability of telecommunications infrastructure to carry information. The measurement unit depends on the facility. A data line's capacity might be measured in bits per second while the capacity of a piece of equipment might be measured in numbers of ports.

CapEx: See Capital Expenditure.

Capital Expenditure (CapEx): Business expense to acquire or upgrade physical assets such as buildings, machinery, network infrastructure, etc. Also called capital spending or capital expense.

Carrier Neutral Location: A CNL is a local peering point location where multiple middle mile providers can meet and provide service to multiple last mile providers.

CATV: See Community Antenna Television.

CaTV: See Cable Television.

CDMA: See Code-Division Multiple Access.

Cellular: Denoting or relating to a mobile telephone system that uses a number of short-range radio stations to cover the area that it serves.

Census Block: The smallest level of geography designated by the US Census Bureau which may approximate actual city street blocks in urban areas. In rural districts census blocks may span larger geographical areas to cover a more dispersed population.

Center for Information Technology Leadership (CITL): See http://www.citl.org/.

Central Office (CO): A telephone company facility in a locality to which subscriber home and business lines are connected on what is called a local loop. The CO has switching equipment that can switch calls locally or to long-distance carrier phone offices.

Churn: The number of subscribers who leave a service provider over a given period of time, usually expressed as a percentage of total customers.

CITL: See Center for Information Technology Leadership.

CLEC: See Competitive Local Exchange Carrier.

Cloud: Some refer to the entire Internet as a cloud – the idea being that all the information is just out there and it does not matter where. More commonly, cloud computing refers to services such as Amazon's S3 where users pay a fee to store information on Amazon's servers without ever really knowing the physical location. Cloud services may include storage, applications, and other services. As we gain access to faster Internet connections (particularly upstream speeds) cloud services may offer a more efficient means of accomplishing tasks and more reliable backup solutions.

CNL: See Carrier Neutral Location.

CO: See Central Office.

Code-Division Multiple Access (CDMA): Any of several protocols used in so-called second-generation (2G) and third-generation (3G) wireless communications.
As the term implies, CDMA is a form of multiplexing which allows numerous signals to occupy a single transmission channel optimizing the use of available bandwidth. The technology is used in ultra-high-frequency (UHF) cellular telephone systems in the 800-MHz and 1.9-GHz bands.

Community Anchor Institution (CAI): non-profit and government organizations that provide essential services to the public. Universities, colleges, community colleges, K12 schools, libraries, health care facilities, social service providers, government and municipal offices are all community anchor institutions.

Community Antenna Television (CATV): Early cable television systems were called community antenna television, or CATV, because by nature of their design they used a using antenna for multiple viewers. This was usually done to bring television signals into basins or other areas obstructed from receiving over the air signals. A single antenna would be placed on a hill or other area where signals could be received and cable would be used to distribute the signal to the homes where access was obstructed.

Community Cabinet: A remote switch location designed to support a single service area or footprint.

Community Connect Grant: The Community Connect program serves rural communities where broadband service is least likely to be available, but where it can make a tremendous difference in the quality of life for citizens. The projects funded by these grants will help rural residents tap into the enormous potential of the Internet.

Competitive Local Exchange Carrier (CLEC): The term and concept coined by the Telecommunication Act of 1996 for any new local phone company that was formed to compete with the ILEC.

Conduit: A reinforced tube through which cabling runs. Conduit is useful both to protect cables in the ground and because one can place conduit underground when convenient (like when other utility work is underway) and later blow or pull cable through the conduit.

Connect America Fund (CAF): The reformation of the USF to support broadband deployment.

Core: See Network Core.

Coverage: Refers to the geographic area in which one can obtain service. Sometimes referred to as a service area.

CPE: See Customer Premises Equipment.

Customer Access Point (CAP): The splice location where a subscriber's drop level infrastructure enters the network. May also be called a subscriber Splice Box (SSB).

Customer Drop: See Drop Level Infrastructure.

Customer Premises Equipment: The family of devices used at the customer's location to access network services. Some CPE – like the AP or cable modem – are provided by the network owner or service provider. Other CPE – like telephones and computers – are usually provided by the customer.

DAS: See Distributed Antenna System.

Data Over Cable Service Interface Specifications (DOCSIS): An international telecommunications standard that permits the addition of high-speed data transfer to an existing cable TV (CaTV) system. It is employed by many cable television operators to provide Internet access over their existing infrastructure.

Demand Aggregation: The process of combining several clients' broadband demand into a single purchase.

Dense Wave Division Multiplexing (DWDM): DWDM is a method of using a single fiber strand for multiple logical data paths.

Dig Once Policies: Broadband friendly policies that dictate communications conduit be added to any underground construction effort.

Digital Subscriber Line (DSL): A family of technologies that provide digital data transmission over the traditional copper wires of a telephone network. The common DSL technologies used in the US are Asymmetric Digital Subscriber Line (ADSL) and Very High Speed Digital Subscriber Line (VDSL).

Digital Subscriber Line Access Multiplexer (DSLAM): Technology that concentrates or aggregates traffic in DSL networks. Located in the central office or in a remote terminal.

Distributed Antenna System (DAS): A network of spatially separated antenna nodes connected to a common source via a transport medium that provides wireless service within a geographic area or structure.

DOCSIS: See Data Over Cable Service Interface Specifications.

Distribution Level Infrastructure: Telecommunications infrastructure intended to distribute signal to community cabinets.

Distribution Ring: An element of distribution level infrastructure connecting multiple community cabinets.

Download: Internet connections have two components – a downstream and upstream. Download refers to the rate at which the user's computer can receive data from the Internet.

Downstream: Generic term referring to data traffic going from the network core to the subscriber location.

Drop: See Drop Level Infrastructure.

Drop Level Infrastructure: Drop level infrastructure – often referred to as a "drop" or "customer drop" is the infrastructure that connects the subscriber's premises to the access level infrastructure. Drop level architecture is part of the local loop.

DS1: A digital signal 1 or DS1 (also known as a T1). A T-carrier signaling scheme devised by Bell Labs. DS1 is a widely used standard in telecommunications in North America and Japan to transmit voice and data between devices. DS1 is the logical bit pattern used over a physical T1 line; however, the terms DS1 and T1 are often used interchangeable. Carries approximately 1.544 Mbps.

DS3: A copper digital signal transport with 44.736 Mbps capacity – or 28 T1 lines – or 672 voice lines.

DSL: See Digital Subscriber Line.

DSLAM: See Digital Subscriber Line Access Multiplexer.

Duopoly: A situation in which two companies own all or nearly all of the market for a given type of product or service – that is, a two company monopoly.

DWDM: See Dense Wave Division Multiplexing.

Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA): An approximate measure of a company's operating cash flow based on data from the company's income statement. Calculated by looking at earnings, which are calculated by subtracting OpEx and SG&A from net revenues, before the deduction of interest expense, taxes, depreciation, and amortization. This earnings measure is of particular interest in cases where companies have large amounts of fixed assets which are subjected to large depreciation.

EBITDA: See Earnings Before Interest, Taxes, Depreciation, and Amortization.

EDD: See Ethernet Demarcation Device.

EPON: See Ethernet Passive Optical Network.

ESRI: ESRI (www.esri.com) is the global leader in geographic information systems.

Ethernet Demarcation Device (EDD): The transceiver device that terminates the optical network at the customer premises in an active Ethernet or EPON design. May also be called an access portal (AP) or optical network terminator (ONT).

Ethernet Passive Optical Network (EPON): One of the family of PON offering downstream capacities of up to 1.25 Gbps and upstream capacities of up to 1.25 Gbps shared among a limited number of end users.

Fast Ethernet: A network transmission standard that provides a data rate of 100 Mbps.

FCC: See Federal Communications Commission.

FDMA: See Frequency Division Multiple Access.

Federal Communications Commission (FCC): Federal agency responsible for telecommunications regulation. See http://www.fcc.gov/.

Fiber Optic Splice Case (FOSC): A protective case at a fiber splicing point.

Fiber to the Building (FTTB): One of the families of fiber networks characterized by fiber delivery to a demarcation on or in the building with distribution to multiple tenants within the building through copper or wireless technologies.

Fiber to the Curb (FTTC): One of the families of fiber networks characterized by fiber delivery to the curb. Sometimes FTTC hands the curb to home connection to a copper or wireless technology. Other times, FTTC is simply a place holder with fiber continuing to the address once the address subscribes to service.

Fiber to the Home (FTTH): One of the families of fiber networks characterized by fiber delivery to the home. FTTH is sometimes used synonymously with FTTP.

Fiber to the Node (FTTN): A high-capacity bandwidth approach that uses both fiber and copper wires. Optical fiber is used for the distribution rings from the core of the telco or CaTV network to an intelligent node in the neighborhood where copper wire is used for the local loop connection to the end user.

Fiber to the Premises (FTTP): A fiber deployment/architecture in which optical fiber extends all the way to the customer's premises. Also known as fiber to the home (FTTH) or fiber to the building (FTTB).

Fiber to the "Whatever" (FTTx): A generic term used to encompass the entire family of fiber networks.

FiOS: See Verizon Fiber Optic System.

FirstNet: The First Responder Network Authority (FirstNet) is an independent authority within NTIA chartered to provide emergency responders with the first high-speed, nationwide network dedicated to public safety.

Fisher-Pry Model: A mathematical model used to forecast technology adoption when substitution is driven by superior technology where the new product or service presents some technological advantage over the old one.

Fixed Wireless: Wireless service that uses fixed CPE in addition to (or instead of) mobile portable devices to deliver data services. Fixed wireless solutions have been deployed as a substitute for wired access technologies. For example, it is being used commercially in the US by Clearwire with WiMax and Stelera with HSPA.

FOSC: See Fiber Optic Splice Case.

Franchise: A cable company wishing to provide television service in a community historically signed a franchise agreement with the municipal government. The agreement would specify what the community would receive from the cable company in return for access to public rights of way.

FTTB: See Fiber to the Building.

FTTC: See Fiber to the Curb.

FTTH: See Fiber to the Home.

FTTN: See Fiber to the Node.

FTTP: See Fiber to the Premises.

FTTx: See Fiber to the "Whatever".

Gbps: See Gigabit per Second.

Geographic Information System: Geographic information systems are databases of spatial data. GIS systems are used to map traffic flows, contagion patterns, flood plains, and many other geography dependent features – like telecommunications outside plant.

Gig-E: See Gigabit Ethernet.

Gigabit Ethernet: A network transmission standard that provides a data rate of 1,000 megabits per second.

Gigabit Passive Optical Network (GPON): A type of PON offering downstream capacities of up to 2.5 Gbps and upstream capacities of up to 1.25 Gbps shared among a limited number of end users.

Gigabit per Second (Gbps or Gb/s): One billion bits per second. Gbps > Mbps > Kbps.
As a comparison, a high definition movie with surround sound is about 8.3 GB in size. To download this size file with different technology transmission speeds:

	Days	Or Hours	Or Minutes	Or Seconds	
Standard Dial-Up	13.72	329.3	19,761.90	1,185,714	**56 Kbps**
Fast Dial-Up	12.00	288.1	17,291.67	1,037,500	**64 Kbps**
T-1	0.51	12.2	737.78	44,266	**1.55 Mbps**
Standard DSL	0.25	6.1	368.89	22,133	**3 Mbps**
Fast DSL	0.05	1.2	73.78	4,426	**15 Mbps**
Fast Cable	0.03	0.9	55.33	3,320	**20 Mbps**
100 Mbps Fiber	0.007	0.18	11.07	664	**100 Mbps**
1 Gbps Fiber	0.0008	0.018	1.11	66	**1 Gbps**

GIS: See Geographic Information System.

Global System for Mobile Communication (GSM): A second-generation digital mobile cellular technology using a combination of frequency division multiple access (FDMA) and time division multiple access (TDMA). GSM operates in several frequency bands. The standard was jointly developed between European administrations. GSM provides a high degree of security by using subscriber identity module (SIM) cards and GSM encryption.

Gompertz Model: A mathematical model used to forecast technology adoption when substitution is driven by superior technology but purchase depends on consumer choice.

GPON: See Gigabit Passive Optical Network.

Grand Slam: A triple play with cell phone service. Sometimes called a quadruple play.

Greenfield: A plot of land that will soon become a residential or business development. Building a broadband network is cheaper in greenfield developments because roads, sidewalks, lawns, and buildings are not yet impediments to running the necessary wires and the network can be deployed in conjunction with the other utilities.

GSM: See Global System for Mobile Communication.

HFC: See Hybrid Fiber Coaxial.

ICT: See Information Communication Technologies.

ILEC: See Incumbent Local Exchange Carrier.

Incumbent: An existing network owner or service provider.

Incumbent Local Exchange Carrier (ILEC): The dominant local phone carrier within a geographical area. Section 252 of the Telecommunications Act of 1996 defines Incumbent Local Exchange Carrier as a carrier that, as of the date of enactment of the Act, provided local exchange service to a specific area. In contrast, competitive access providers and competitive local exchange carriers (CLECS) are companies that compete against the ILECs in local service areas.

Information Communication Technologies (ICT): Information and communication based technologies.

Inside Plant (ISP): Electronics, wiring, and other accouterments associated with telecommunications networks located within community cabinets, central offices, or other shelters.

Integrated Services Digital Network (ISDN): A set of CCITT/ITU standards for digital transmission over ordinary telephone copper wire as well as over other media. Home and business users who install an ISDN adapter (in place of a telephone modem) receive Web pages at up to 128 Kbps compared with the maximum 56 Kbps rate of a modem connection.

Interconnect: The term interconnect is used in two different ways: a) to describe the connection between a service provider and the Internet – also known as backhaul and b) the logical and physical infrastructure used to connect two non-congruous service areas. In either case, interconnect is usually part of the middle mile infrastructure.

Interexchange Carrier (IXC): A telecommunications service provider authorized by the FCC to provide interstate, long distance communications services and authorized by the state to provide long distance intrastate communications services. Also known as an Interexchange Common Carrier.

Interexchange Common Carrier: See Interexchange Carrier.

International Standards Organization (ISO): The body charged with developing and advertising international standards.

Internet Exchange Point (IXP): See Peering Point.

Internet Protocol Television (IPTV): A method of delivering television services using the Internet Protocol.

Internet Service Provider (ISP): A company or organization that provides a connection to the public Internet, often owning and operating the last mile connection to the end user locations.

Investment Gap: The amount of funding necessary to upgrade or extend existing infrastructure up to the level necessary to support the National Broadband Availability Target. The investment gap is sometimes referred to as the broadband availability gap.

IP: See Internet Protocol.

IPTV: See Internet Protocol Television.

Irrevocable Right of Use (IRU): A method of leasing fiber or other existing telecommunications assets that gives the lease an irrevocable right of use for some period of time. IRU's are typically counted as capital expenses but under some circumstances can be operational expenses.

IRU: See Irrevocable Right of Use.

ISDN: See Integrated Services Digital Network.

ISO: See International Standards Organization.

ISP: See Internet Service Provider or Inside Plant.

IXC: See Interexchange Carrier.

IXP: See Internet Exchange Point.

Kbps: See Kilobits per Second.

Kilobits per Second (Kbps): A measure of transmission speed. Kbps < Mbps < Gbps.
As a comparison, a high definition movie with surround sound is about 8.3 GB in size. To download this size file with different technology transmission speeds:

	Days	Or Hours	Or Minutes	Or Seconds	
Standard Dial-Up	13.72	329.3	19,761.90	1,185,714	**56 Kbps**
Fast Dial-Up	12.00	288.1	17,291.67	1,037,500	**64 Kbps**
T-1	0.51	12.2	737.78	44,266	**1.55 Mbps**
Standard DSL	0.25	6.1	368.89	22,133	**3 Mbps**
Fast DSL	0.05	1.2	73.78	4,426	**15 Mbps**
Fast Cable	0.03	0.9	55.33	3,320	**20 Mbps**
100 Mbps Fiber	0.007	0.18	11.07	664	**100 Mbps**
1 Gbps Fiber	0.0008	0.018	1.11	66	**1 Gbps**

Last Mile: Describes the final leg of a connection between a service provider and the customer and is often synonymous with the local loop. In DSL and cable systems, this is the most common bandwidth bottleneck.

LATA: See Local Access and Transport Area.

Latency: The amount of time it takes for a bit to get from point A to point B.

LEC: See Local Exchange Carrier.

Levelized: A method, often used in regulatory proceedings, to calculate the annuitized equivalent – i.e., the effective annual value of cash flows – of the costs and revenues associated with building and operating a network. A "levelized" calculation provides a steady cash-flow stream rather than trying to model or guess the timing of largely unpredictable yet sizeable real-world payouts like those for upgrading and repairing equipment. The present value of a levelized cash flow is equal to the present value of actual cash flows.

Line of Sight: Requiring an unimpeded view from one site to another.

Link Budget: A calculation involving the gain and loss factors associated with the antennas, transmitters, transmission lines and propagation environment used to determine the maximum distance at which a transmitter and receiver can successfully operate along a link.

LMG: Louisville Metro Government.

Local Access and Transport Area (LATA): One of 196 local geographical areas in the US created by the Modified Final Judgment in which a divested Regional Bell Operating Company (RBOC) was permitted to offer local exchange telecommunications and local exchange access services.

Local Exchange Carrier (LEC): A regulatory term in telecommunications for a local telephone company.

Mbps: See Megabit per Second.

MDU: See Multiple Dwelling Unit.

Megabit per Second (Mbps): A measurement of data connectivity speed. Kbps < Mbps < Gbps.
As a comparison, a high definition movie with surround sound is about 8.3 GB in size. To download this size file with different technology transmission speeds:

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Standard Dial-Up	13.72	329.3	19,761.90	1,185,714	**56 Kbps**
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100 Mbps Fiber	0.007	0.18	11.07	664	**100 Mbps**
1 Gbps Fiber	0.0008	0.018	1.11	66	**1 Gbps**

Metropolitan Optical Ethernet (MOE): CenturyLink's branding for fiber to the premises.

Microwave: Microwave transmission refers to the technique of transmitting information over microwave frequencies using various integrated wireless technologies. Microwaves are short wavelength high frequency signals that occupy the electromagnetic spectrum 1 GHz to roughly 300 GHz. This is above the radio frequency range and below the infrared range. Microwave transmissions can travel a long distance but must be line of sight.

Mid-State: See Mid-State Consultants.

Mid-State Consultants: A Utah based telecommunications engineering firm. See www.mscon.com for more information.

Middle Mile: Middle mile is a term most often referring to the network connection between the last mile and the greater Internet. Middle mile infrastructure is sometimes referred to as backhaul.

Mobile Switching Center (MSC): The mobile switching center connects the landline public switched telephone network (PSTN) system to the wireless communications system. The MSC is typically split into a mobile switching center server and a media gateway and incorporates the bearer independent call control.

Mobile Wireless: Data connectivity from a cellular network.

MOE: See Metropolitan Optical Ethernet.

MPLS: See Multiprotocol Label Switching.

MSC: See Mid-State Consultants or Mobile Switching Center.

MSO: See Multi-System Operator.

MTFB: See Mean Time Between Failures.

MTU: See Multiple Tenant Unit.

Multi-System Operator (MSO): Typically refers to a firm that owns more than one cable television network infrastructure.

Multiple Dwelling Unit (MDU): A building or property with multiple individual residential addresses like an apartment building.

Multiple Tenant Unit (MTU): A building or property with multiple individual business addresses like a strip mall or office building.

Multiprotocol Label Switching (MPLS): A mechanism in high-performance telecommunications networks which directs and carries data from one network node to the next. MPLS makes it easy to create "virtual links" between distant nodes. It can encapsulate packets of various network protocols.

National Association of Telecommunications Officers and Advisors (NATOA): NATOA is comprised of local government officials and employees that work on cable and broadband issues – from public access television to managing the community's rights of way.

National Broadband Availability Target: The level of service set in the National Broadband Plan that should be available to every household and business location in the U.S. The initial target is an actual download speed of at least 4 Mbps and an upload speed of at least 1 Mbps, with a proposed review and update every four years.

National Broadband Plan: A Federal Communications Commission plan to improve Internet access in the United States.

National Telecommunications and Information Administration (NTIA): A division of the Department of Commerce.

NATOA: See National Association of Telecommunications Officers and Advisors.

Natural Monopoly: A monopoly in an industry in which it is most efficient (involving the lowest long-run average cost) for production to be concentrated in a single firm.

Network Management System (NMS): A combination of hardware and software used to monitor and administer a computer network or networks. Individual network elements in a network are managed by an element management system.

Network Operations and Dispatch Center (NODC): When a network operations center also has crew dispatch functions it is sometimes called a network operations and dispatch center.

Network Operations Center (NOC): The centralized location where the network is monitored and restoration, maintenance, and operations are coordinated.

Network Owner: An organization owning (and possibly operating) telecommunications infrastructure.

NMS: See Network Management System.

NOC: See Network Operations Center.

NODC: See Network Operations and Dispatch Center.

Node: An active or passive element in a cable or telephone system where neighborhood distribution (or access level infrastructure) begins. Often a node is where fiber transitions to copper local loop infrastructure.

Node Splitting: In a cable system, adding infrastructure so that subscribers previously served by a single node are moved to multiple nodes reducing the number of subscribers per node.

NTIA: See National Telecommunications and Information Administration.

OECD: See Organization for Economic Cooperation and Development.

OFAP: See Optimal Fiber Allocation Plan.

ONT: See Optical Network Termination.

Open Access Network: A network designed and operated on the principal of a wholesale/retail split in which the network owner makes wholesale infrastructure and services available to competing service providers who provide retail services to end customers.

Open Systems Interconnect (OSI): The ISO model that defines the seven layers of activity in a data communication network.

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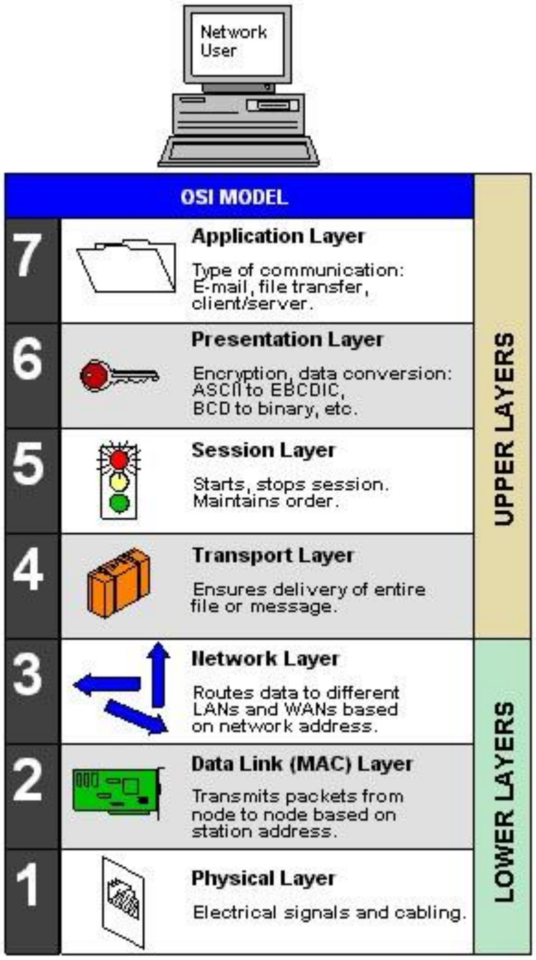

Operational Expense (OpEx): An expense a business incurs over the course of its normal operations. Examples include product overhead, employee salaries and electric bill payments. Importantly, operating expenses on a balance sheet reflect only ordinary expenses rather than unexpected, one-time expenses. One subtracts the operating expense from operating revenue to determine the operating profit.

OpEx: See Operational Expense.

Optical Network Termination (ONT): The device in a PON architecture that terminates the optical network at the customer's premises. In many active architectures the parallel device is called an AP or EDD}

Optimal Fiber Allocation Plan (OFAP): In designing a fiber network, engineers must take into consideration the cost of aggregation points vs. the cost of the fiber plant itself. The OFAP describes the balance point where the greatest efficiency in both aggregation and fiber plant is achieved.

Organization for Economic Cooperation and Development (OECD): The mission of the OECD is to promote policies that will improve the economic and social well-being of people around the world.
The 30 member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

OSI: See Open Systems Interconnect.

OSP: See Outside Plant.

OTT: See Over the Top.

Outside Plant (OSP): The outside plant is that portion of the physical network that delivers services to the subscribers' homes that lies between the CO or node and the premises demarcation. Outside plant consists of conduit, fiber, cable, handholes, communications shelters, and other elements.

Outside Plant System of Record: The outside plant system of record is any system used as the definitive record of the outside plant.

Over Subscription Rate: The ratio of retail bandwidth to wholesale bandwidth used by and ISP to manage bandwidth costs.

Over the Top: Services carried over an Internet connection. For example, OTT video would include video delivered by Hulu or YouTube.

Overbuild: The process of deploying a network in an already developed area – usually where existing telecommunications networks already exist.

Overlash: The process of adding additional cable to an existing aerial route.

P2P: See Peer to Peer.

PARCC: See Partnership for Assessment of Readiness for College and Careers.

Partnership for Assessment of Readiness for College and Careers (PARCC): An organization that creates a standard set of K-12 assessments in math and English.

Passive Optical Network (PON): A fiber architecture that shares bandwidth with multiple subscribers through passive splitters.

PBX: See Private Branch Exchange.

PCS: See Personal Communications Service.

Peer to Peer: A type of network or service that allows computers to connect directly to each other rather than organizing them via hierarchical connections.

Peering: A relationship between two or more ISPs in which the ISPs create a direct link between each other and agree to forward each other's packets directly across this link.

Peering Point: A physical location where peering occurs.

PEG: See Public Access, Education, and Government.

Personal Communications Service (PCS): The FCC term used to describe a set of 2G mobile communications digital cellular technologies working over CDMA, GSM, and TDMA air interfaces

Plain Old Telephone Service (POTS): The basic single line switched access service offered by local exchange carriers to residential and business end users, using loop-start signaling.

Point of Presence (PoP): A physical location where one network hands off to another.

PON: See Passive Optical Network.

PoP: See Point of Presence.

POTS: See Plain Old Telephone Service.

Primary Revenue: Revenue created from direct charges.

Private Branch Exchange (PBX): A telephone system within an enterprise that switches calls between enterprise users on local lines while allowing all users to share a certain number of external phone lines.

PSTN: See Public Switched Telephone Network.

Public Access, Education, and Government (PEG): These are commonly programming options made available to the community by the cable company as part of its franchise agreement.

Public Switched Telephone Network (PSTN): The worldwide collection of interconnected public telephone networks that was designed primarily for voice traffic. The PSTN is a circuit-switched network, in which a dedicated circuit (also referred to as a channel) is established for the duration of a transmission, such as a telephone call. This contrasts with packet switching networks, in which messages are divided into small segments called packets and each packet is sent individually. Packet switching networks were initially designed primarily for data traffic.

QOS: See Quality of Service.

Quadruple Play: A triple play with cell phone service. Sometimes called a "Grand Slam".

Quality of Service (QOS): The ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow in a data network.

Radio Frequency Over Glass (RFoG): An evolutionary technology that allows cable companies to offer an all-fiber architecture (not hybrid-fiber coax) without changing modulation schemes. RFoG is a standard in development for Point to Multipoint (P2MP) operations that has a proposed wavelength plan compatible with data PON solutions including EPON and 10G-EPON.

RBOC: See Regional Bell Operating Company.

Regional Bell Operating Company (RBOC): Local exchange carriers formed after the breakup of AT&T in 1984. The seven regional holding companies (RHCs) of roughly equal size were formed as a result of the 1982 Consent Decree AT&T signed with the US Department of Justice, stipulating that it would divest itself of its 22 wholly owned telephone operating companies. The seven RHCs were Ameritech, Bell Atlantic, BellSouth, NYNEX, Pacific Telesis, Southwestern Bell and US West. After a series of acquisitions, mergers and name changes (including one in which a combination of several RHCs reclaimed the original AT&T name), only three of the original seven remain. They are AT&T, CenturyLink, and Verizon.

Regional Tandem: A tandem switch is an intermediate switch or connection between an originating telephone call or location and the final destination of the call. These are hub facilities that interconnect telephone central office exchanges and are deployed by geographical region within a telco LATA or exchange.

RFI: Request for Infomration.

RFoG: See Radio Frequency Over Glass.

Right of Way (ROW): The legal right, established by usage or grant, to pass along a specific route through grounds or property belonging to another.

ROW: See Right of Way.

Rural Utilities Service (RUS): A division of the US Department of Agriculture. RUS has a division responsible for providing low interest loans to telecommunications network owners to deploy broadband technologies in rural areas.

RUS: See Rural Utilities Service.

SDV: See Switched Digital Video.

Second Mile: Generally refers to the transport and transmission of data communications from the first point of aggregation to the greater Internet or the peering point. Sometimes called middle mile or backhaul.

Secondary Revenue: Revenue generated through taxes or fees unrelated to the primary purpose of the assets.

Selling, General and Administrative Expense (SG&A): Corporate overhead costs, including expenses such as marketing, advertising, salaries and rent. SG&A is found on a corporate income statement as a deduction from revenues in calculating operating income.

Service Area: An area served by a community cabinet.

Service Provider: An organization providing telecommunications or broadband services.

Set Top Box (STB): The device used to translate IPTV or other digital television signals to useful information to the customer's television.

SG&A: See Selling, General and Administrative Expense.

Signal to Interface plus Noise Ration (SINR): For a wireless communications device, the ratio of the received strength of the desired signal to the received strength of undesirable signals (noise and interference).

SIM: See Subscriber Identity Module.

SLIGP: See State and Local Implementation Grant Program.

Spectrum Allocation: The amount of spectrum dedicated (or allocated) to a specific use. In wireless, spectrum allocation is typically made in paired bands with one band for upstream and the other for downstream.

SSB: See Subscriber Splice Box.

State and Local Implementation Grant Program (SLIGP): The Middle Class Tax Relief and Job Creation Act of 2012 authorized the creation of the first nationwide broadband network for public safety, the First Responder Network Authority (FirstNet). The law also directed NTIA to develop a grant program for states to support planning, education and outreach as they consult with FirstNet on the deployment of the broadband network, which will enable first responders to better communicate during emergencies and save lives. NTIA's State and Local Implementation Grant Program gives states the resources needed to consult with FirstNet on deployment of a nationwide public safety broadband network.

STB: See Set Top Box.

Subscriber Splice Box (SSB): The splice location where a subscriber's drop level infrastructure enters the network. May also be called a customer access point (CAP).

Switched Digital Video (SDV): A network scheme for distributing digital video via a cable more efficiently to free up bandwidth for other uses. Only channels being watched by end users in a given node are transmitted to that node.

Symmetrical: Internet connections have two components - a downstream and upstream. When the two speeds are comparable, the connection is termed symmetric. Fiber-optic networks more readily offer symmetrical connections than DSL and cable, which are inherently asymmetrical. Ultimately, purely symmetrical connections are less important than connections which offer robust connections in both directions. However, many asymmetrical connections via DSL and cable networks offer upload speeds that are too slow to take advantage of modern applications.

T1: A mode of frequency division multiplexing that provides 1.544 Mbps or 24 voice channels. Sometimes called DS1.

TA: See Terminal Adapter.

Take Rate: Represents the number of subscribers divided by the number of potential subscribers. There are several different models for defining both subscribers and potential subscribers.

TCP/IP: See Transmission Control Protocol/Internet Protocol.

TDM: See Time Division Multiplexing.

TDMA: See Time Division Multiple Access.

Telco: *Tel*ephone *Co*mpany. A provider of telecommunications services such as voice and data services. Also called common carriers or Local Exchange Carriers.

Telecommunication Act of 1996: Current US federal law governing telecommunications regulation.

Telepresence: Refers to a variety of methods to use technology to make it seem like a person in a remote location is present. The more bandwidth available, the more realistic the telepresence.

Terminal Adapter (TA): The CPE device used to convert VOIP signals to traditional telephone signals so customers do not require specialized telephones.

Tier 1 Network: An Internet Protocol network that participates in the Internet solely via settlement-free interconnection, also known as settlement-free peering.

Tier 2 Network: An Internet service provider who engages in the practice of peering with other networks, but who still purchases IP transit to reach some portion of the Internet.

Tier 3 Network: Used to describe networks who solely purchase IP transit from other networks (typically Tier 2 networks) to reach the Internet.

Time Division Multiple Access (TDMA): Technology used in digital cellular telephone communication that divides each cellular channel into three time slots in order to increase the amount of data that can be carried. TDMA is used by Digital-American Mobile Phone Service (D-AMPS), Global System for Mobile communications (GSM), and Personal Digital Cellular (PDC). Each of these systems implements TDMA in somewhat different and potentially incompatible ways. An alternative multiplexing scheme to FDMA with TDMA is CDMA (code division multiple access), which takes the entire allocated frequency range for a given service and multiplexes information for all users across the spectrum range at the same time.

Triple Play: The three main services offered over modern broadband networks - television, phone services, and Internet access - comprise the triple play. Many consumers like to get all three from the same service provider on the same bill. Service providers frequently offer deals that will lower the cost on these packages.

UMTS: See Universal Mobile Telecommunications System.

Uninterruptable Power Supply (UPS): A batter device that continues to deliver power to connected electronics when other power fails.

United States Department of Agriculture (USDA): See http://www.usda.gov/wps/portal/usda/usdahome.

Universal Mobile Telecommunications Service (UMTS): Third-generation (3G) broadband, packet-based transmission of text, digitized voice, video and multimedia at data rates up to and possibly higher than 2 Mbps, offering a consistent set of services to mobile computer and phone users. Based on the Global System for Mobile (GSM) communication standard.

Universal Service Fund (USF): A federal program funded by telecommunications surcharges with four programs: high cost (subsidizes the high cost of services in rural areas), low income (includes Lifeline and Link Up discounts to those in poverty), rural health care (reduced rates to rural health care providers to ensure they have access to similar services as urban counterparts), and schools and libraries (E-Rate subsidizes telecommunication services to schools and libraries).

Unserved: Those addresses without access to a broadband network capable of offering service that meets the National Broadband Availability Target.

Upload: Internet connections have two components - a download and upload. Upload refers to the rate at which the user's computer can send data to the Internet. DSL and cable networks frequently offer upload speeds at only 1/10 of the download speeds. This is one of the main reasons DSL and cable networks are insufficient for the modern Internet.

UPS: See Uninterruptable Power Supply.

Upstream: Generic term referring to traffic going from the subscriber location towards the network core.

USDA: See United States Department of Agriculture.

USF: See Universal Service Fund.

Unbundle: The process of making network elements available to competing service providers.

U-Verse: see AT&T U-Verse.

Verizon Fiber Optic System (FiOS): FiOS (Fiber Optic Service) is a "fiber to the home" (FTTH), implementation undertaken by Verizon. A typical FiOS package includes high-speed Internet access along with cable TV and basic telephone service. For consumer use, FiOS Internet access is available at downstream speeds between 15 and 300 megabits per second (Mbps) and upstream speeds between 5 and 65 Mbps.
Verizon has built its FiOS network in most of the states where it offers landline communications services.

Virtual Local Area Network (VLAN): A method of using common carrier networks to include disparate devices on the same broadcast domain.

Virtual Private Network (VPN): A set of protocols used to build and secure a private connection through a public network.

VLAN: See Virtual Local Area Network.

Voice Over Internet Protocol (VOIP): A method of delivering voice services over an IP (packet switched) network.

VOIP: See Voice Over Internet Protocol.

VPN: See Virtual Private Network.

Wholesale Retail Split: One description of the telecommunications business model wherein the network owner and the retail service provider are not the same entity.

Wi-Fi: Wi-Fi is a suite of protocols that allow wireless devices to exchange information using unlicensed frequencies. Equipment carrying the Wi-Fi brand is interoperable. Recently, a number of cities and some private companies attempted to blanket their cities with Wi-Fi but the technology is not well suited to such large scale efforts. Wi-Fi has proved tremendously successful in homes and businesses.

WiMax: Worldwide Interoperability for Microwave Access (WiMAX) is a telecommunications technology that uses radio spectrum to transmit bandwidth between digital devices. Similar to WiFi, WiMAX brings with it the ability to transmit over far greater distances and to handle much more data.

Wireless: Unwired telecommunications; either fixed wireless or mobile wireless.

Wireless Internet Service Provider (WISP): An Internet service provider that provides fixed or mobile wireless services to its customers. Using Wi-Fi or proprietary wireless methods, WISPs provide last mile access, often in rural areas and areas in and around smaller cities and towns.

WISP: Wee Wireless Internet Service Provider.

7.2 References

7.2.1 Useful Web Sites

- Baller Herbst Law Group Community Broadband. http://www.baller.com/comm_broadband.html.
- Broadband.gov. http://www.broadband.gov/.
- Brookings Institute Broadband Policy. http://www.brookings.edu/research/topics/broadband-policy.
- CivSource. http://civsourceonline.com/.
- Columbia Institute for Tele-Information (CITI) at Columbia Business School. http://www8.gsb.columbia.edu/citi/.
- Community Broadband Networks. http://www.muninetworks.org/. Institute for Local Self-Reliance.
- Computer Desktop Encyclopedia. http://www.computerlanguage.com/. Provides definitions of information technology terms and concepts.
- Digital Communities. http://www.digitalcommunities.com/.
- FCC Antenna Structure Registration – Registration Search. http://wireless2.fcc.gov/UlsApp/AsrSearch/asrRegistrationSearch.jsp. Provides FCC registered antenna structure data.
- FCC Public Safety and Homeland Security Bureau: Broadband and Public Safety. http://transition.fcc.gov/pshs/broadband.html.
- Google Analytics: Global Broadband Performance. http://www.google.com/publicdata/explore?ds=z8ii06k9csels2_#!strail=false&bcs=d&nselm=s&ifdim=region&hl=en_US&dl=en_US&ind=false.
- Fiber to the Home Council. http://www.ftthcouncil.org/.
- HTTP Archive. http://httparchive.org/.

- Information Technology and Innovation Foundation. http://www.itif.org/.
- Institute for Local Self-Reliance: Broadband. http://www.ilsr.org/initiatives/broadband/.
- Kentucky Broadband Map. http://www.bakerbb.com/kybroadbandmapping/.
- Level 3 Interactive Network Map. http://maps.level3.com/default/. Map of Level 3 fiber assets.
- Missouri Broadband. http://mobroadbandnow.com/.
- MobilePulse. http://www.mobilepulse.com/.
- National Broadband Plan. http://www.broadband.gov/.
- Net Index. http://www.netindex.com/.
- NTIA: Public Safety. http://www.ntia.doc.gov/category/public-safety.
- Pew Internet and American Life Project. http://pewinternet.org/.
- Speed Matters. http://www.speedmatters.org/.
- State of Utah Broadband Project: Public Safety. http://broadband.utah.gov/resources/public-safety/.
- TelcoData.us: Telecommunications Database. http://www.telcodata.us/. Consolidates and presents significant information on telephone exchanges.
- Telecom Ramblings. http://www.telecomramblings.com/. Provides insight into the telecommunications industry.
- TestMy.Net. http://testmy.net/. Speed test site.
- US Census. http://www.census.gov/.
- USDA Rural Development. http://www.rurdev.usda.gov/utp_farmbill.html.
- Your Dictionary. http://www.yourdictionary.com/. Used for some term definitions.

7.2.2 References and Recommended Reading

ABB Tropos (15 March 2007). "Savannah, GA Deploying Public Safety and Municipal Wi-Fi Networks Citywide with Tropos System." Viewed 7 November 2013 at http://www.tropos.com/news/pressreleases/2007_03_15.php.

American Telephone and Telegraph Company (16 March 1909). "1908 Annual Report of the Directors of American Telephone and Telegraph Company to the Stockholders." Viewed 24 November 2012 at http://www.beatriceco.com/bti/porticus/bell/pdf/1908ATTar_Complete.pdf.

Anderson, Ken (28 August 2013). "Remote Monitoring Technology Improves Safety, Security." Brownfield. Viewed 7 November 2013 at http://brownfieldagnews.com/?s=remote+monitoring+technology.

Appian Communications (2001). "Carrier-Class Ethernet: A Services Definition." Appian Communications White Paper.

Atkinson, Robert D., Daniel K. Correa and Julie A. Hedlund (May 2008). "Explaining International Broadband Leadership." The Information Technology and Innovation Foundation. Retrieved 12 September 2011 from http://www.itif.org/files/ExplainingBBLeadership.pdf.

Banerjee, Anupam and Marvin Sirbu (June 2008). "FTTP Industry Structure: Implications of a wholesale retail split." Carnegie Mellon University. Retrieved 12 September 2011 from http://web.si.umich.edu/tprc/papers/2006/648/Banerjee_Sirbu%20TPRC_2006.pdf.

Bilbao-Osorio, Benat, Soumitra Dutta, and Bruno Lanvin, Editors (2013). "The Global Information Technology Report 2013: Growth and Jobs in a Hyperconnected World." World Economic Forum and INSEAD. http://www3.weforum.org/docs/WEF_GITR_Report_2013.pdf.

Blandin Foundation (no date). "Municipal Options for Fiber Deployment." http://www.blandinfoundation.org/_uls/resources/Municipal_Options_final.pdf.

Bode, Karl (24 January 2012). " If You're Waiting on FiOS, You Could be Waiting a While: 30% of Verizon Customers May Wait Years for Upgrades." Broadband DSL Reports. http://www.dslreports.com/shownews/118039.

Bode, Karl (9 February 2012). "AT&T: The U-Verse Build is Over: Like FiOS, if You didn't get it already, you probably won't." Broadband DSL Reports. http://www.dslreports.com/shownews/ATT-The-UVerse-Build-is-Over-118297.

Broadband.gov (no date). "What is Broadband?" FCC. http://www.broadband.gov/about_broadband.html.

Broadband Properties (June 2012). "Municipal FTTH Deployment Snapshot: Utah Telecommunication Open Infrastructure Agency (UTOPIA)." Broadband Properties Magazine; May/June 2012. http://www.bbpmag.com/snapshot/snap0612.php.

Broadband USA Applications Database (26 March 2010). "Utah Telecommunication Open Infrastructure Agency Community Partnership Project." National Telecommunications & Information Administration. http://www.ntia.doc.gov/legacy/broadbandgrants/applications/summaries/5714.pdf.

Brocade Communications Services (2009). "What is Carrier Grade Ethernet?" Brocade Communications Systems.

Browning, Jonathan and Cornelius Rahn (6 January 2012). "Verizon Fixed-Line Sale Would Enable Vodafone Combination, Goldman Says." Bloomberg. http://www.bloomberg.com/news/2012-01-06/vodafone-lifted-to-buy-at-goldman-sachs-on-verizon-strength.html.

Caspi, Heather (2 August 2012). "Experts Present Update on Broadband for Public Safety." Firehouse. http://www.firehouse.com/news/10754689/experts-present-update-on-broadband-for-public-safety.

CBS 5 New Channel, Cheyenne, WY – Sottsbluff, NE (23 October 2012). "Governor Talks Technology, Broadband. Viewed 7 November 2013 at http://www.kgwn.tv/story/19896928/governor-talks-technology-broadband.

Center for Information Technology Leadership (2007). "The Value of Provider-to-Provider Telehealth Technologies." Healthcare Information and Management System Society (HIMMSS); Charlestown, MA. Google books extract at http://books.google.com/books?id=mn0oaG-0zfgC&printsec=frontcover#v=onepage&q&f=false.

Cisco. "Cisco Visual Network Index: Forecast and Methodology, 2012-2017." Cisco. Viewed 18 November 2013 at http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360.pdf.

Cohen, David L. (24 May 2013). "US the Leader on Broadband." Philadelphia Inquirer. Viewed 18 November 2013 at http://articles.philly.com/2013-05-24/news/39478428_1_broadband-connectivity-mbps-access.

Cohill, Andrew Michael (1 February 2012). "Community-Owned Conduit." Posted as a reply to Christopher Mitchell's article, "Smart Conduit Considerations for Forward-Looking Communities" at http://www.muninetworks.org/content/smart-conduit-considerations-forward-looking-communities.

Coleman, Rick, James Behunin, and Matthew Harvey (August 2012). "A Performance Audit of the Utah Telecommunication Open Infrastructure Agency." Office of the Legislative Auditor General State of Utah. http://le.utah.gov/audit/12_08rpt.pdf.

Columbia Telecommunications Corporation (January 2007). "Fiber Optics for Government and Public Broadband: A Feasibility Study." http://www.ctcnet.us/SFFiberFeasibilityReport.pdf.

Columbia Telecommunications Corporation (September 2009). "Benefits Beyond the Balance Sheet: Quantifying the Business Case for Fiber-to-the-Premises in Seattle." http://www.seattle.gov/broadband/docs/SeattleFTTNBenefits_091109.pdf.

Cooper, Mark (1 July 2002). "The Importance of ISPs in the Growth of the Commercial Internet: Why Reliance on Facility-Based Competition will not Preserve Vibrant Competition and Dynamic Innovation on the High-Speed Internet". Consumer Federation of America Texas Office Public Utility Counsel. Viewed 3 December 2013 at http://www.consumerfed.org/pdfs/ispstudy070102.pdf.

Crandall, Robert W., William Lehr, and Robert Litan (July 2007). "The Effects of Broadband Deployment on Output and Employment: A Cross-Sectional Analysis of U.S. Data." The Brookings Institute Issues in Economic Policy; Washington, DC. http://www.brookings.edu/views/papers/crandall/200706litan.pdf. http://www.brookings.edu/~/media/research/files/papers/2007/6/labor%20crandall/06labor_crandall.pdf.

Crawford, Stephanie (no date). "How Fast Should My Internet Connection be to Watch Streaming HD Movies?" How Stuff Works. Viewed 18 November 2013 at http://entertainment.howstuffworks.com/fast-internet-connection-for-streaming-hd-movies.htm.

Czernich, Nina, Oliver Falck, Tobias Kretschmer, and Ludger Woessman (December 2009). "Broadband Infrastructure and Economic Growth." CESIFO Working Paper. http://www.cesifo.de/pls/guestci/download/CESifo%20Working%20Papers%202009/CESifo%20Working%20Papers%20December%202009/cesifo1_wp2861.pdf.

Daily, Geoff (28 January 2008). "Internet Reinforces Local Bonds." AppRising. Viewed 1 March 2012 at http://www.app-rising.com/2008/01/internet_reinforces_local_bond.html.

FCC (March 2010). Connecting America: The National Broadband Plan. http://www.broadband.gov/plan/. In early 2009, Congress directed the Federal Communications Commission (FCC) to develop a National Broadband Plan to ensure every American has "access to broadband capability." Congress also required that this plan include a detailed strategy for achieving affordability and maximizing use of broadband to advance "consumer welfare, civic participation, public safety and homeland security, community development, health care delivery, energy independence and efficiency, education, employee training, private sector investment, entrepreneurial activity, job creation and economic growth, and other national purposes." Broadband networks only create value to consumers and businesses when they are used in conjunction with broadband-capable devices to deliver useful applications and content. To fulfill Congress's mandate, the plan seeks to ensure that the entire broadband ecosystem—networks, devices, content and applications— is healthy. It makes recommendations to the FCC, the Executive Branch, Congress and state and local governments.

Ferguson, Charles H. (2004). The Broadband Problem: Anatomy of a Market Failure and a Policy Dilemma. Brookings Institution Press.

Ferguson, Charles H. and Charles R. Morris (1994). Computer Wars. Random House Times Books.

Fiber to the Home Council (May 2013). "Becoming a Fiber-Friendly Community: Regulatory and Infrastructure Actions that can Drive Deployments." Fiber to the Home Council. http://www.ftthcouncil.org/p/bl/et/blogaid=214&source=1.

Fishburn, Jeff (2006). "Broadband Fiber-to-the-Home Technologies, Strategies, and Deployment Plan in Open Service Provider Networks: Project UTOPIA". In Chinlon Lin Broadband Optical Access Networks and Fiber-to-the-Home: Systems Technologies and Deployment Strategies. John Wiley & Sons; Chichester, UK.

Ford, George S. and Thomas M. Koutsky (April 2005). "Broadband and Economic Development: A Municipal Case Study from Florida." Applied Economic Studies; April 2005. http://www.aestudies.com/library/econdev.pdf.

Graziano, Dan (28 February 2013). "Time Warner Cable Executive Claims Consumers don't want Gigabit Internet." BGR. Viewed 18 November 2013 at http://bgr.com/2013/02/28/google-fiber-time-warner-cable-347728/.

Gillett, Sharon E., William H. Lehr, Carlos A. Osorio, and Marvin A. Sirbu (28 February 2006). "Measuring Broadband's Economic Impact." Prepared for the U.S. Department of Commerce, Economic Development Administration. http://cfp.mit.edu/publications/CFP_Papers/Measuring_bb_econ_impact-final.pdf.

Gladwell, Malcolm (29 February 2000). The Tipping Point: How Little Things can make a Big Difference. Little, Brown and Company.

Gonzalez, Lisa (22 May 2012). "Green Lighting In Chattanooga – Savings, Safety and Jobs." Community Broadband Networks. http://muninetworks.org/tags-263.

Greaves, Thomas W. and Jeanne Hayes (2008). "America's Digital Schools 2008: The Six Trends to Watch." The Greaves Group; The Hayes Connection. http://www.schooldata.com/pdfs/ADS08_intro.pdf.

Greene, Wedge and Barbara Lancaster (18 March 2007). "Carrier-Grade: Five Nines, the Myth and the Reality." LTC International – published in Pipeline Magazine in April 2007.

Hansell, Saul (19 August 2008). "A Bear Speaks: Why Verizon's Pricey FiOS Bet Won't Pay Off." New York Times Bits. http://bits.blogs.nytimes.com/2008/08/19/a-bear-speaks-why-verizons-pricey-fios-bet-wont-pay-off/.

Harford, Tim (18 January 2008). "How Email Brings You Closer to the Guy in the Next Cubicle." Wired; Issue 16 Volume 2. http://www.wired.com/culture/lifestyle/magazine/16-02/st_essay.

Horrigan, John and Ellen Satterwhite (December 2012). "TechNet's 2012 State Broadband Index". TechNet. http://www.technet.org/wp-content/uploads/2012/12/TechNet_StateBroadband3a.pdf.

Hussain, Hibah, Daniel Kehl, Patrick Lucey, and Nick Russo (2013). "The Cost of Connectivity 2013". The New America Foundation; Washington, DC. Viewed 18 January 2014 at http://newamerica.net/sites/newamerica.net/files/policydocs/Cost_of_Connectivity_2013_Data_Release.pdf.

Kalish, Shlomo (1985). "A New Product Adoption Model with Price, Advertising and Uncertainty," Management Science, Vol. 32, No. 12, December, pp. 1569-1585.

Keymile (2008). "Ethernet Point-to-Point vs. PON – A Comparison of Two Optical Access Network Technologies and the Different Impact on Operation". Keymile.

Kushnick, Burce (19 May 2012). “The Great Verizon FiOS Ripoff.” Huffington Post. Viewed 11 October 2012 at http://www.huffingtonpost.com/bruce-kushnick/the-great-verizon-fios-ripoff_b_1529287.html.

Levin, Blair (27 March 2013). “FCC Gigabit Communities Workshop”. FCC. Viewed 22 November 2013 at http://transition.fcc.gov/presentations/03272013/Blair-Levin.pptx.

Manross, G. Gary and Everett M. Rogers (2002). “Closing the Chasm… Introducing New Products/Services into the Marketplace by Integrating Diffusion of Innovations with Product Life Cycle.” Strategic Research Institute.

Mitchell, Bradley (no date). “How Fast Does Your Network Need to Be?” About.com. Viewed 18 November 2013 at http://compnetworking.about.com/od/speedtests/tp/how-fast-does-your-network-need-to-be.htm.

National Telecommunications and Information Administration and Economics and Statistics Administration (June 2013). “Exploring the Digital Nation: America’s Emerging Online Experience.” US Department of Commerce. Viewed 11 November 2013 at http://www.ntia.doc.gov/files/ntia/publications/exploring_the_digital_nation_-_americas_emerging_online_experience.pdf.

Netflix (no date). “Internet Connection Speed Recommendations.” Netflix. Viewed 18 November 2013 at https://support.netflix.com/en/node/306.

Nuechterlein, Jonathan E. and Philip J. Weiser (4 February 2005). Digital Crossroads: American Telecommunications Policy in the Internet Age. MIT Press; Cambridge, MA.

OECD (September 2012). “Average and Median Advertised Download Speeds.” Retrieved 10 October 2013 from http://www.oecd.org/sti/broadband/BB-Portal-5a.xls.

Partnership for Assessment of Readiness for College and Careers (September 2013). “Technology Guidelines for PARCC Assessments: Version 3.0”. Partnership for Assessment of Readiness for College and Careers. Viewed 8 November 2013 at http://www.parcconline.org/sites/parcc/files/TechnologyGuidelinesforPARCCAssessmentsV3.0Sept2013.pdf.

Peterson, Jess (8 March 2012). “Broadband Keeping America’s Farmers and Ranchers Connected as they Feed the World.” Broadband for America. Viewed 7 November 2013 at http://www.broadbandforamerica.com/blog/broadband-keeping-america%E2%80%99s-farmers-and-ranchers-connected-they-feed-world.

Pugh, Catherine (15 August 2013). “The False Promise of Municipal Broadband: Local Governments Keep Building Expensive Networks that Fail to Attract Customers.” The Baltimore Sun. http://www.baltimoresun.com/news/opinion/oped/bs-ed-broadband-20130815,0,2185759.story.

Pugmire, Genelle (20 December 2013). “UTOPIA Announces Partnership with Private Capital Company”. Daily Herald. Viewed 21 January 2014 at http://www.heraldextra.com/news/local/central/orem/utopia-announces-partnership-with-private-capital-company/article_e364dbb4-6901-11e3-ad10-0019bb2963f4.html.

Qiang, Christine Zhen-Wei, Carlo M. Rossotto, and Kaoru Kimura (13 January 2009). “Economic Impacts of Broadband.” In Information and Communications for Development pp 35-50. The World Bank. http://siteresources.worldbank.org/EXTIC4D/Resources/IC4D_Broadband_35_50.pdf.

Ratliff, Lee (7 June 2010). “Verizon’s FTTH Expansion Stoppage Takes Many by Surprise.” iSuppli Market Watch. Viewed 1 December 2013 at http://www.isuppli.com/Home-and-Consumer-Electronics/MarketWatch/Pages/Verizons-FTTH-Expansion-Stoppage-Takes-Many-by-Surprise.aspx.

Rice, Douglas (no date). "Broadband and the Hospitality Industry". Viewed 5 November 2013 at http://10yearsofbroadband.com/public/images/pdf/Douglas%20Rice%20Hotel%20Technology%20Next%20Generation.pdf.

Rintels, Jonathan (2008). "An Action Plan for America: Using Technology and Innovation to Address our Nation's Critical Challenges: A Report for the new Administration from the Benton Foundation." Benton Foundation. http://benton.org/sites/benton.org/files/Benton_Foundation_Action_Plan.pdf.

Rogers, Everett M. (1983). Diffusion of Innovations (3rd edition). New York, NY: The Free Press.

Said Business School (1 October 2009). "Global Broadband Quality Study Shows Progress, Highlights Broadband Quality Gap." University of Oxford. http://www.sbs.ox.ac.uk/newsandevents/Documents/BQS%202009%20final.doc.

Said Business School (2010). "Third Annual Broadband Study Shows Global Broadband Quality Improves by 24% in One Year."

Salway, David. "National Broadband Map Data Called Into Question." About.com. http://broadband.about.com/od/broadbandavailability/a/National-Broadband-Map-Data-Called-Into-Question.htm.

Salway, David (May 2012). "Broadband as and Economic Driver". About.com. http://broadband.about.com/od/economicdevelopment/a/Broadband-As-An-Economic-Driver.htm.

Singer, Hal J. and Jeffrey D. West (2 March 2010). "Economic Effects of Broadband Infrastructure Deployment and Tax Incentives for Broadband Deployment." Fiber to the Home Council. http://www.ftthcouncil.org/d/do/72.

Speedmatters.org (no date). "Speed Matters." http://www.speedmatters.org/benefits/archive/economic_growth_quality_jobs/.

Speed Matters (November 2010). "2010 – A Report on Internet Speeds in All 50 States." Communications Workers of America; Washington DC. Retrieved 24 January 2012 from http://cwa.3cdn.net/299ed94e144d5adeb1_mlblqoxe9.pdf.

Swanson, Bret (14 October 2010). "International Broadband Comparison, Continued." Maximum Entropy. It is based on data at Cisco Visual Networking Index (VNI); http://www.cisco.com/en/US/netsol/ns827/networking_solutions_sub_solution.html.

Tessler, Joelle (6 February 2009). "Broadband Funding in Stimulus Plan Sparks Debate." USA Today. http://www.usatoday.com/tech/news/2009-02-06-broadband-funding_N.htm.

US Census Bureau (2011). "Reported Internet Usage for Individuals 3 Years and Older." Viewed 11 November 2013 at http://www.census.gov/hhes/computer/files/2011/table1.xls.

US District Court for the District of Columbia (24 Aug 1982). "United States of America, Plaintiff, v. Western Electric Company, Incorporated, and American Telephone and Telegraph Company, Defended: Civil Action No. 82-0192. Modification of Final Judgment." US District Court for the District of Columbia.

US DOT (2005). "Intelligent Transportation systems for Traffic Signal Control." http://ntl.bts.gov/lib/jpodocs/brochure/14321_files/a1019-tsc_digital_n3.pdf.

Utah Telecommunication Open Infrastructure Agency (26 November 2003). "White Paper: Utah's Public-Private Fiber-to-the-Premises Initiative." Utah Telecommunication Open Infrastructure Agency. http://broadband.cti.gr/en/download/Utah_fiber.pdf.

Van Gaasbeck, Kristin, Stephen Perez, Ryan Sharp, Helen Schaubmayer, Angela Owens, and Lindsay Cox (November 2007). "Economic Effects of Increased Broadband Use in California Research Report."

Sacramento Research Institute. http://www.strategiceconomicresearch.org/AboutUs/EconEffectsBB_Research.pdf.

Waverman, Leonard, Kalyan Dasgupta, and Justin Tonkin (18 January 2008). "The Connectivity Scorecard." LECG Nokia Siemens Networks.

Weber, Roland and Thomas Jahrig (26 March 2010). "'AOSI' Improving Road Safety on Rural Roads in Germany." Viewed 8 November 2013 at http://www.4ishgd.valencia.upv.es/index_archivos/16.pdf.

White, Richard (2012). Railroaded: The Transcontinentals and the Making of Modern America. WW Norton & Company.